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Pastures of Puerto Rico and their relation to Soil Conservation

Miscellaneous
Publication
Number 513

FOREWORD

It is admitted generally that the diet of the Puerto Rican population is deficient in animal proteins. The consumption of more milk and meats depends on a larger supply at lower than present costs and on an increase in the income of the people. With nearly 2 million people and only approximately 2 million acres of all land in Puerto Rico, it is clear that the acreage per head necessary to support cattle must be reduced.

Grasses constitute the main source of food for our cattle. This study of pastures fills a gap that has long existed in our work. The information will serve as the basis for many studies that should be started at the point where the writers stop. The agronomist interested in the improvement of grasses and the ecological relations and the animal husbandman concerned with their biological value will find it expeditious to continue in logical sequence from this publication to their own research studies.

At the time this manuscript was prepared the unhappy events that led to our participation in the present world conflict had not even been considered possible. The island of Puerto Rico is called on to produce animal feeds that were formerly imported from the United States. The practical farmers or livestock men will find useful information in the pages of this publication, which will help them to meet the exigencies of the war emergency. Of special interest to them is the information on the kinds of pasture, their improvement, and management. One cannot lose sight, of course, of the role of pastures in soil conservation in the Tropics.

This publication can be considered as the result of coordination of efforts by two agencies, the Soil Conservation Service and the Agricultural Experiment Station of the University of Puerto Rico.

J. A. B. NOLLA, *Director*
Agricultural Experiment Station,
University of Puerto Rico.

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PASTURES OF PUERTO RICO AND THEIR RELATION TO SOIL CONSERVATION

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United States Department of Agriculture in cooperation with the Agricultural Experiment Station, University of Puerto Rico

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INTRODUCTION

Pastures play an important role in soil conservation in Puerto Rico. The island is located in the Tropics, and is subjected to soil erosion throughout the year. When the torrential rains fall on tilled land, they carry large quantities of topsoil down the slopes to the sea. After the tilled land no longer is productive, largely as a result of loss of soil, it frequently is abandoned and the volunteer herbage in many of the areas is used for pasture. Although most of the land that is tillable is used for crops other than pasture, some farmers have found it profitable to turn their land to pasture. The erosion in well-managed pastures on sloping land is negligible in comparison with that which occurs on tilled slopes.

The information in this publication is based upon the results that were obtained at the Soil Conservation Research Station at Rio Piedras, Puerto Rico, supplemented in a large measure by information obtained directly through interviews with small and large land owners,

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[1] Acknowledgment is made to G. L. Crawford, formerly director of the Soil Conservation Service in Puerto Rico and the Virgin Islands, for the many constructive criticisms and suggestions with regard to the subject matter and its organization; to Joseph J. Stroup, soil conservationist, for reviewing some of the chapters; to J. A. B. Nolla, director of the Agricultural Experiment Station of the University of Puerto Rico, for his constant interest in the progress of the work; to S. L. Descartes, head of the Department of Agricultural Economics, for his helpful suggestions on economic phases of the pasture survey in relation to soil conservation; to J. I. Otero, experiment station librarian, for his critical reading of the manuscript and helpful suggestions for its improvement; and to all others from whom valuable suggestions and constructive criticisms were obtained from time to time.

"medianeros,"[2] dairy men, beef cattle producers, and livestock managers on sugar centrals. At the station a study was made of the grasses that could be utilized both for erosion control and pasture, in an endeavor to assist the farmers in improving their lands and raising their standard of living.

The results of field investigations and interviews indicate that there is a considerable area of scattered lands on which volunteer grasses are available during part of the year but which are not utilized in a manner to obtain maximum gains, also that there are large areas on which nonpalatable species of grasses, briers, and brush form the predominating vegetation.

An attempt is made in this publication to show not only the methods of establishing, maintaining, and improving lands that are already in pasture, but also to show methods of utilizing the present so-called idle lands, so that human foods in the form of dairy products and meat can be obtained in greater amounts. The idle lands can be made more productive for pasturage within a period of from 6 to 10 months. During times of peace, when it was more profitable from the standpoint of immediate financial returns to abandon land that was not suitable for growing cash crops, little attention was given to utilizing it for pasture, and consequently land that could have produced good pasturage was often neglected. With the present immediate need of all the food products that can possibly be made available on the island it becomes necessary to utilize all the available land. That which is not suitable for the production of food crops should be given special attention and be utilized for the production of maximal yields of forage.

Fundamental principles based upon actual farm practices in various parts of the island are presented. Methods of pasture improvement that conserve the soil and increase yields are discussed. This information is of immediate value not only to farmers and livestock men in Puerto Rico but also to those of neighboring tropical islands.

PASTURE LANDS

During the past century there was a great change in the percentage of land utilized for pasture in Puerto Rico. As late as 1828 only 3 percent of the total area of land was under cultivation, 24 percent was in pasture, and the remainder was still in forest, brush, and swampland (table 1). At the close of the nineteenth century the cultivated area had increased to 12 percent and the pasture area to more than 50 percent. For many decades prior to this period there was a considerable export trade in livestock, hides, and tallow. In 1905 the area in pasture was 57 percent of the total area of the island. With the development of sugarcane, tobacco, citrus, and pineapple culture, great inroads were made on the pasture lands; they were pushed to the poorer and more rugged areas formerly occupied by forests.

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[2] Persons who work on the farms for wages during the planting and harvesting season and who are permitted to construct a cabin on the land to provide a home for themselves and their families. In addition, they are allowed to raise a crop of vegetables on a small piece of land, which may be in a different place on the farm from year to year. Frequently they keep a cow. The rental that they pay is usually half of the crop that they raise on this tract, hence the term "medianero."

Exports in animals and animal products have ceased entirely. Cultivated land has encroached upon the pasture land and reduced it to approximately two-fifths of its peak acreage.

TABLE 1.—*Land use in Puerto Rico in 1828, 1900, 1912, 1935*

Land use	Proportion of total acreage			
	1828 [1]	1900 [1]	1912 [1]	1935 [2]
	Percent	*Percent*	*Percent*	*Percent*
Cultivation	3	12	23	38
Pasture	24	52	47	34
Timber, brush, swamp, public and other use	73	36	30	28

[1] MURPHY, L. S. FORESTS OF PORTO RICO . . . THEIR PHYSICAL AND ECONOMIC ENVIRONMENT. U. S. Dept. Agr. Bul. 354, p. 11. 1916.

[2] Calculation based on data given in the UNITED STATES CENSUS OF AGRICULTURE, 1935.

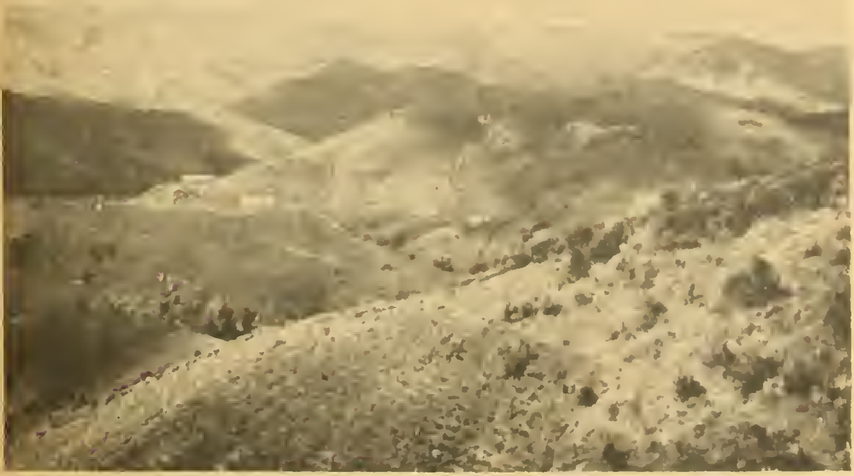
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FIGURE 1.—Nearly all tillable land is planted to crops.

The tillable cropland of the island constitutes approximately 825,000 acres, of which almost 15 percent is classed as idle. The idle land is occupied by volunteer vegetation that consists primarily of various species of native grasses that are grazed by cattle belonging to the owner of the land or by cattle belonging to the medianeros.

Nearly all the area of the island is potential pasture land. Native grasses thrive wherever the forests have been removed. Owing to the density of population, which now exceeds 500 persons per square mile, nearly all the tillable land has been planted to crops at one time or another—even the steep hillsides where the soil is shallow and subject to severe erosion (fig. 1). Most of the hillside lands formerly were subjected to primitive agricultural practices. The forest trees were felled and set on fire. Sometimes the larger ones were girdled and left standing. Beans, bananas, corn, rice, yautias, and other crops were planted on the burned-over areas, where the ashes had enriched and sweetened the soil. Little cultivation was given these crops, and the cropping system seldom continued for more than 3 years. Eventually, as the fertility of the soil decreased and the surface soil was lost by erosion and as grasses and other volunteer vegetation took possession of the land, the area was abandoned and a new clearing was made. The practice has been discontinued since the population has become so dense that there are no forest lands left to be cleared in this manner.

Strictly pasture lands constitute approximately 750,000 acres, of which 87 percent is on cleared land and the remainder is woodland pasture. The pastures on cleared land are found where other crops cannot be grown profitably or where the farm enterprise, like dairying near cities, is organized so that pasturage is more profitable than crops that require tillage. The pasture lands are distributed among the cropland areas throughout the island. There are exceptions, however, in that the mountainous and foothill regions south of the central divide, where the land is not suitable for irrigation, and the entire southwest portion of the island, where irrigation water is not available, are devoted almost exclusively to pastures. The cleared pastures may be classified roughly according to the prevalence of soil moisture and according to topography.

Wet lowlands.—Some lowlands near streams are too wet for the production of cultivated crops. These lands are used for pasture during the dry season and for the production of grasses to be cut and fed green during the wet season. Pará grass (*Panicum purpurascens*) and Carib grass (*Eriochloa polystachya*) are the principal grasses in such areas. These areas are subject to periodic floods during the wet season, and cattle are exposed to foot and intestinal parasites if grazed on them during this period.

Moist undulating lowlands.—Some lowlands that have adequate surface drainage but underlain with heavy clay subsoil are not suitable for most kinds of crops that require intertillage. Cattle are grazed generally on such lands. Although the yield of pasturage is low, the lands will not produce a cultivated crop economically. Such areas generally are occupied by tropical carpet grass (*Axonopus compressus*) and cintillo or sour paspalum (*Paspalum conjugatum*).

Dry lowlands.—These lands are found mainly on the south and southwest coasts of the island. Those that are suitable for irrigation are planted to sugarcane. Others are pastured. The yield of forage is comparatively low. The main grasses are paraguita (*Chloris inflata*) and serrillo (*Sporobolus indicus*). Where the soils are saline, a condition due perhaps to comparatively recent geological uplift of the lands above sea level, there is still a considerable stand of beachgrass or seashore dropseed, (*Sporobolus virginicus*), which is a pioneer grass ecologically and is generally found only a short distance from the seashore. This grass is low in palatability and yield and constitutes poor pasturage.

On the north coast, where the soil is sandy and subject to seasonal droughts, the grass coverage consists mainly of Thalia lovegrass (*Eragrostis ciliaris*), abrojo or southern sandbur (*Cenchrus echinatus*), and Bermuda grass (*Cynodon dactylon*). The last named species is prevalent in fields that formerly have been in cultivation.

Large areas of sandy soils along the coast are utilized as coconut groves. Some coconut growers operate dairy farms. The land among the trees is planted to Pará grass and elephant grass or Napier grass (*Pennisetum purpureum*). The Pará grass is grazed and the elephant grass is cut and fed green.

Moist uplands.—Moist uplands that are used for pasture are found in the northern part of the island, especially in the "haystack"[3] hill region, where the soil originated from calcareous rock and is underlain by it from several inches to a foot or more below the surface. These areas are occupied mainly by St. Augustine grass (*Stenotaphrum secundatum*) and serrillo.

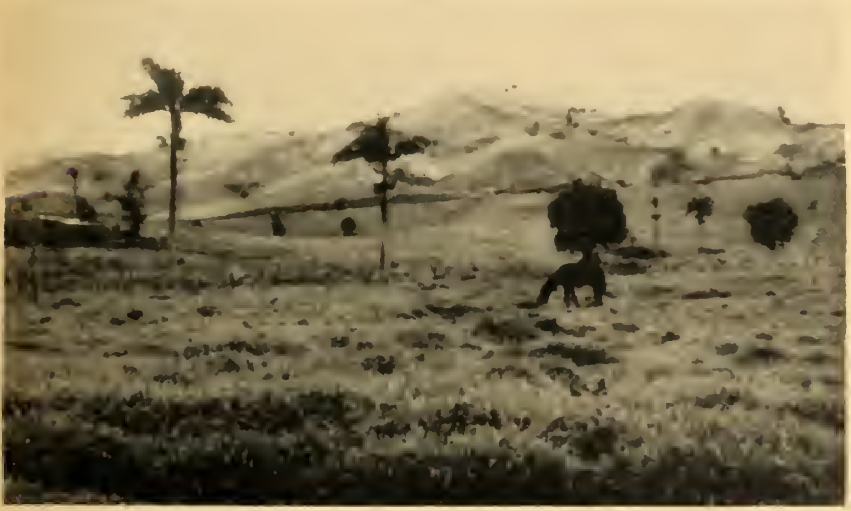

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FIGURE 2.—Upland pastures. Guinea grass in foreground. Serrillo on the slopes

Dry uplands.—Dry uplands are found on the south and the southwest sides of the island. Where the soil is more than 6 inches deep the main grass is serrillo. This native grass has been replaced rather generally by planted guinea grass (*Panicum maximum*) (fig. 2). Where the soil is shallower it is occupied generally by lamilla (*Bouteloua heterostega*). Guinea grass that is planted on such shallow soils is subjected to being pulled up by the roots by grazing animals.

Croplands.—Where one of the main sources of income is from dairying, some farmers rotate croplands with pastures. Such pasture areas are planted to Carib grass and Pará grass in the northeastern part of the island, and to guinea grass in the region west and south of Arecibo. More frequently, however, croplands are abandoned when they no longer are productive and are allowed to grow to volunteer grasses consisting of such annuals as jungle-rice (*Echinochloa colo-*

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[3] MEYERHOFF, H. A. GEOLOGY OF PUERTO RICO. Puerto Rico Univ. Monog. Phys. and Biol. Sci. Ser. B, No. 1, p. 80. 1933.

num) and Jamaica fingergrass or pata de gallina fina (*Digitaria horizontalis*), also called pendejuelo, locally, which is the name for *Paspalum decumbens*, on the north side of the island, and redtop millet (*Panicum adspersum*) and paraguita in the dry region on the south side. These grasses are followed by others in succession depending upon the length of the time the land remains idle. Frequently there is a thick stand of Bermuda grass immediately following abandonment.

Woodland pastures.—There are almost 100,000 acres of woodland pastures. These are located primarily on slopes on the south side of the divide that are too steep for cultivation (fig. 3), in the open savanna lands between the seacoast and the foothills, and in the coffee region in the west-central part of the island. The number of trees per unit area is decidedly variable and ranges from a few to many trees per acre. The native grasses in these pastures on the steep slopes on the south side of the divide comprise mainly serrillo, which is distributed throughout the area, and, at the higher elevations, sporadic or, in some places, thick stands of rabo de zorra or sourgrass (*Trichachne insularis*). At lower elevations south and west of the divide, lamilla is the predominating native grass. The main native grasses in the savanna lands between the foothills and the coast in the vicinity of Ponce and Salinas are serrillo, buffel grass (*Pennisetum ciliare*), and paraguita. Many of the woodland pastures south of the divide have been improved by planting guinea grass. In the coffee region of the west-central part of the island the principal woodland pasture grasses are tropical carpet grass, St. Augustine grass, and serrillo.

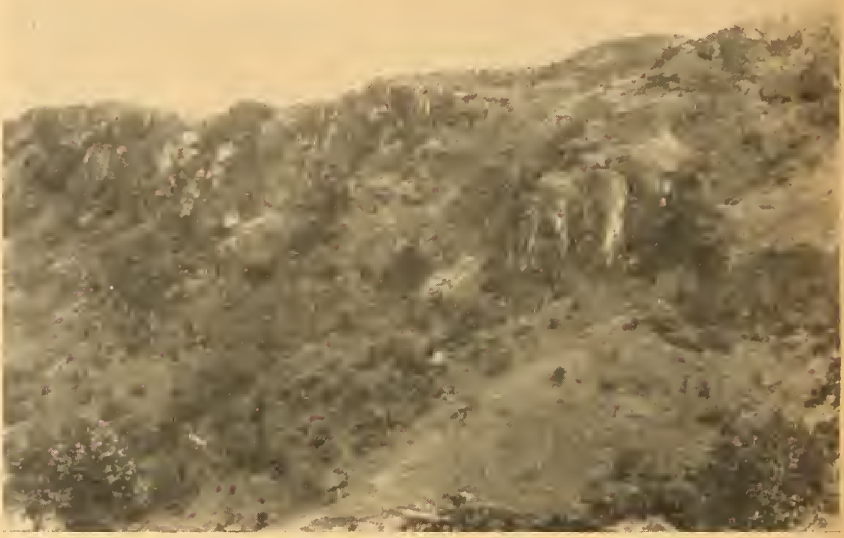
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FIGURE 3.—Woodland pasture.

Abandoned cropland.—Land that has been tilled and subsequently retired from cultivation is soon covered with vegetation, principally grasses. There are two main stages of growth and development of the grasses. One is an annual stage, which may be either seasonal or indeterminate, and the other is, more strictly speaking, a succession of grasses that ends in a climax formation over a period of years. The number of native species of annuals and perennials in Puerto Rico is approximately equal. The annual grasses such as colchoń (*Andropogon brevifolius*) and carruzo (*Panicum trichanthum*) are adapted to the seasonal droughts, during which period they are in the seed stage and vegetative development ceases almost entirely. Other annuals like gazon or Panama paspalum (*Paspalum fimbriatum*) and Jamaica fingergrass develop in bare places among other grasses and grow rapidly at any season of the year when the ground is sufficiently moist for seed germination and subsequent growth. They have no definite seasonal blooming period. Some species of grasses, such as St. Augustine grass, serrillo, lamilla, and pajon or Angleton grass (*Andropogon annulatus*) thrive well on an undisturbed compact soil, where they may become the climax grasses in some pastures. On the other hand, species that respond quickly to tillage, such as Bermuda grass, cintillo, jungle-rice, redtop millet, and paraquita, offer competition. In well-managed pastures there is a tendency for the grasses and other vegetation to maintain a continuous harmonious ground cover that protects the soil against erosion.

CLASSES OF LIVESTOCK ON PASTURE

Almost all the classes of farm animals that are pastured in temperate climates are pastured also in the tropical island of Puerto Rico. Oxen and goats constitute a large percentage of the total livestock. The number of animals raised primarily for beef is comparatively small.

Dairy cattle.—Dairy cattle are distributed widely throughout the island. The greatest number of dairy herds is found in close proximity to cities, to supply the population with bottled milk that retails at from 10 cents to 20 cents a quart. In most instances the milk is bottled at the farm and delivered directly to the consumer. The prevalent breeds are Holstein, Guernsey, Jersey, and crosses with native stock. In sections remote from cities in the extreme southwestern part of the island, where animals of the native types are raised primarily for the production of work stock, a considerable amount of milk is also produced, although the average yield per individual cow is only 2 or 3 quarts a day. Some cheese, similar to cottage cheese is produced, mainly for home consumption. A factory at Arecibo and another at Camuy produce cheese on a commercial scale. Butter production is negligible. Ice cream is also made and sold from some of the dairies.

Oxen.—Oxen are used as draft animals, especially in the sugarcane fields. Native cattle are used primarily. Many oxen were formerly imported from the Virgin Islands. This importation ceased about 1935, when the cattle tick eradication campaign was begun in Puerto Rico. In the southern part of the island, a considerable number of native animals have been crossed with Brahman cattle or zebus in order to produce a stronger and more hardy animal. During the "zafra," or sugarcane harvesting season, oxen are fed primarily on cane tops. During the remainder of the year they are pastured.

Beef cattle.—Although the number of animals that are raised expressly for beef production is small, some are slaughtered for beef. The zebu crosses that cannot be used for work oxen because of the position of their horns are destined for the block. Animals that have poor horns or that have horns that extend backward cannot be hitched because in Puerto Rico the yokes are fastened to the horns and not to the shoulders of the animals. Another source of beef supply is from native surplus steers that cannot be used for work animals. A considerable amount of beef comes also from oxen that are too old to work and from old dairy cows.

Horses, mules, and donkeys.—Horses are used by overseers for riding about sugar plantations to supervise the work and for pack animals to carry provisions to and from remote places to the highways, from there to be taken to cities by trucks and automobiles. The animals weigh approximately from 600 to 800 pounds. They are for the most part the progeny of stock that was introduced into the island by Ponce de Leon early in the sixteenth century, and those introduced from New England in the 18th century.[4] Mules are used as draft animals, and donkeys are used primarily as pack animals. Grass is usually cut and fed green to these animals, which are pastured when they are not in use, if pasture is available.

Goats.—Goats are kept by many poor families in rural districts in Puerto Rico. They are raised for their meat and for milk production for family consumption. A small quantity of goat cheese is made.

In rural districts some of the goats are pastured in the same fields with cattle. In most instances, however, the goats are kept by the medianeros, who tie them near their houses. Part of the time they run loose, especially when there are no crops to which they can do much damage. Although these animals graze wherever they may find grass, a considerable amount of their subsistence in rural sections consists of browse.

Numerous goats are also kept by families that live in urban districts. Most of them are fed on cut green feed in addition to that obtained by grazing and browsing.

Sheep.—The number of sheep that are raised on the island is comparatively small. They are pastured throughout the year. They are hairy and have little wool. They are utilized primarily for mutton production. Dogs sometimes play havoc with the flock. From the standpoint of utilization of the animals by individual families the goat is more profitable as well as more hardy.

Hogs.—Although hogs are distributed throughout the island, the number of animals owned by a family is usually not more than one or two or perhaps a few more if the litter happens to be large and the pigs are not sold to neighbors or other local buyers. The individual hogs are tethered from place to place and have been trained to lead on a leash. Frequently they run loose about the habitation. Little attention is given to pasturage. Some cut grass is fed to them. The animals generally subsist on such refuse as yautia peelings, malanga roots, cassava roots, sweetpotatoes, and anything else that they may find to be edible. Some of the native animals that are now on farms are said to be descendents of the breeds that were brought to Aguada by Yanez Pinzon in 1505. Much improvement has been made in the native stock by crossing them with superior introduced breeds, such as Hampshire, Duroc Jerseys, Poland China, and Tamworth. Government agencies, such as the Extension Service, Division of Vocational Agriculture, and Department of Agriculture of Puerto Rice, have played an important part in swine improvement by introducing pedigreed boars and sows from the United States.

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[4] Bidwell, P. W., and Falconer, J. I., history of agriculture in the northern United States, 1620–1860. Carnegie Inst. Wash. Pub. 358, p. 113. 1941.

MAJOR PASTURE GRASSES

Of major importance are the climax grasses in the various parts of the island (fig. 4). Tillage changes the natural environment in which the climax grasses compete successfully with other species. Most of the climax grasses are adapted to a compact soil that never has been disturbed by the plow. Relatively slow, as a rule, in reestablishing themselves after the soil has been tilled, they take possession of the land almost to the exclusion of other species after they have once been established. Although guinea grass is not a native grass of Puerto Rico, it is included in the list of major grasses.

Guinea grass.—This grass is the most important pasture grass on the island (fig. 5). It is believed that it was first introduced at Arroyo on the south side of the island early in the sixteenth century from seed that was in the straw that was used for bedding of the human cargo of a slave ship that came here directly from Africa.[5] Guinea grass is grown on nearly all land on the south side of the island that cannot be utilized for sugarcane production and also on a limited area on the north side of the island west of Arecibo. One of the environmental requirements for the best development of the plant is a well-drained fertile soil that has a neutral or slightly alkaline reaction and that is not subject to continuous saturation of moisture for several days at a time. Guinea grass tolerates periods of prolonged drought and resumes its growth rapidly after showers.

It grows to a height of from 3 to 7 feet, depending upon the fertility of the soil and the distribution of rainfall. The plant tillers profusely (see cover picture) and enlarges into tufts of more than a foot in diameter. Under favorable conditions it grows so tall that the cattle are hard to find in the pasture even by men on horseback. Sometimes the tufts are so close to one another that it is difficult to determine where one ends and the other begins.

Guinea-grass seed is harvested by hand. The panicles are collected and spread out to dry. Seed that is stored is threshed by beating the heads, and is then placed in containers, usually in old oil drums. If seed is brought from a dry region to one where the relative humidity of the atmosphere is high, it soon loses its viability. Little seed is available on the market.

Although the young plants are highly palatable, they act as a purgative for cattle and horses. Cattle sometimes lose weight when they graze on young guinea-grass pasture. The grass retains a relatively high degree of palatability and nutritive value in its advanced stages of growth. Also butchers prefer animals that have been grazed on nearly mature grass to those that have been fattened on

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[5] COLON, E. D. DATOS SOBRE LA AGRICULTURA DE PUERTO RICO ANTES DE 1898. P. 284. San Juan, Puerto Rico. 1930.

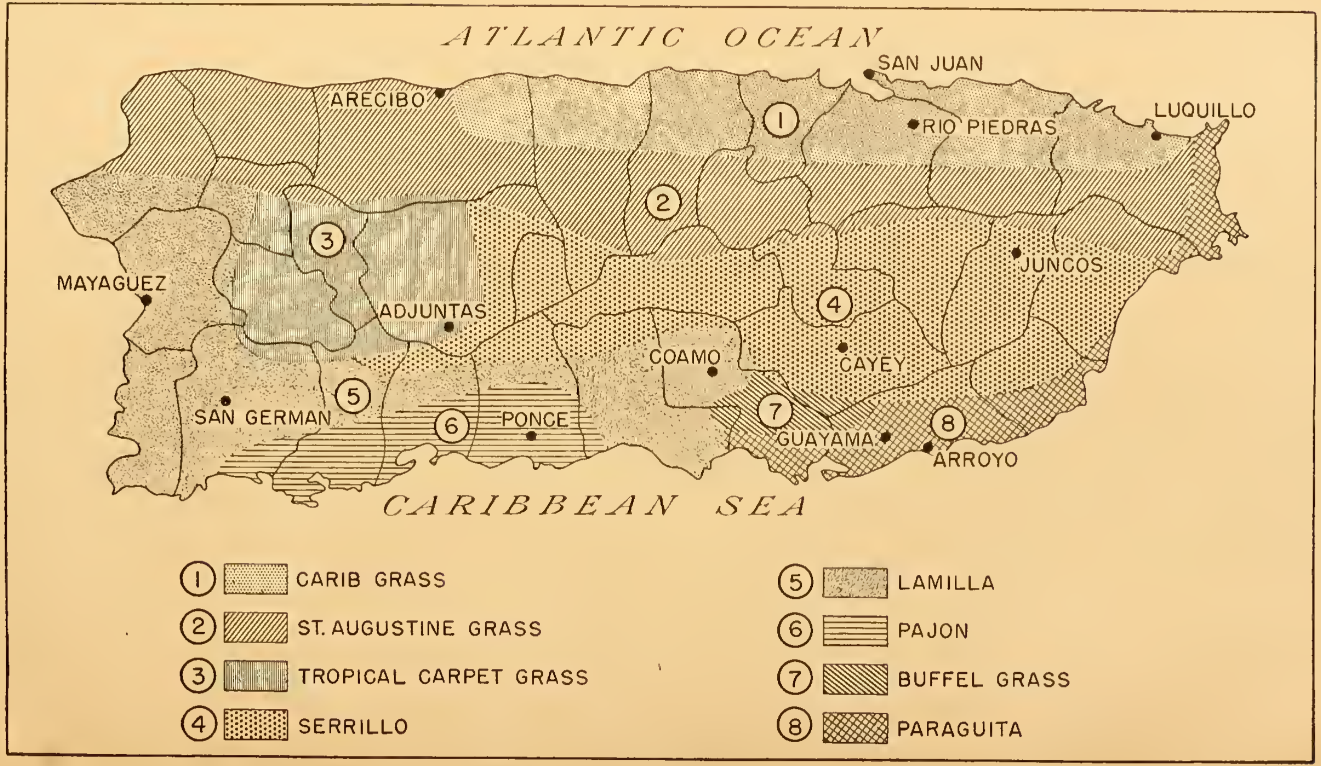

FIGURE 4.—Map of Puerto Rico showing approximate distribution of predominating native pasture grasses.

young grass because the former yield a higher percentage of meat when dressed.

Carib grass.—Carib grass, known locally as malojilla, and Pará grass comprise the most valuable pasture and soilage grasses in the lowlands of the northeastern part of the island. Carib grass dominates in this region. It grows to a height of approximately 3 to 4 feet above the ground. The trailing culms are sometimes 2 feet to 15 feet long. The leaves are dark green in color. It thrives best in soils that are relatively wet, but it will grow also on well-drained upland soils.

Carib grass grows wild in lowlands that are subjected to inundations several times a year. Such areas require no special attention, except plowing with a primitive plow each year to destroy numerous crowns that have become senescent, in order to make room for the new growth. It is not necessary to replant because enough culms remain uncovered by the plow to revegetate the area through volunteer growth. The first culms that form will trail along the ground until the entire area is covered. Then they assume an upright position, and the intervening spaces become occupied by erect plants that originate from the nodes of the trailing culms.

C-6460

FIGURE 5.—Guinea grass pasture.

It is necessary to practice rotational grazing. If Carib grass pastures on uplands are grazed short throughout one year practically all the plants will succumb. Care must be exercised in pasturing the fresh grass. Some cases of bloating have been reported where hungry animals were turned on young pasture.

Pará grass.—Pará grass is similar to Carib grass in general appearance. It may be distinguished from the latter by its thicker, more hairy stems and its larger leaves that are lighter green in color. It blooms from October to December while Carib grass blooms throughout the year. During the nonblooming period, Pará grass can be distinguished readily in the field from Carib grass by its hairy nonflowering stems that project several inches above the stems of Carib grass. Its cultural practices and economic value are similar to those of Carib grass with which it generally grows in association.

Serrillo.—Serrillo is important in the botanical composition of pastures in Puerto Rico. It will grow on practically all types of soil on the island. It prefers a clay soil to a sandy soil and tolerates both slightly acid and alkaline soil reactions. It grows over a wide range of moisture conditions from moderately wet to extremely dry. It does not tolerate soil that is saturated with water for a long period of time. On the other hand, it will grow in small crevices on cliffs where the amount of soil is extremely small and where most other types of vegetation will not thrive.

Serrillo is a tuft-forming grass that propagates by seed and enlargement of the tufts. It blossoms throughout the year and produces seeds profusely. The tufts expand radially through tillering of the plant. Under favorable conditions the tufts may attain a diameter of 4 inches or more, but generally the diameter is considerably less because of poor soil and competition from other grasses. Narrow, tender leaves grow from the base of the plant. Wiry culms emerge among the leaves from the base of the plant and grow to a height of from 10 to 20 inches. The leaves emerge rapidly after having been grazed. Culms develop more slowly.

The abundance of serrillo is limited principally by tillage and plant competition. It is easily subdued in cultivation and will reestablish itself rather slowly in abandoned fields.

On the north side of the island, where the soil is deep, moist, and well drained it plays a minor role, the ground being occupied by St. Augustine grass and tropical carpet grass. Plants develop only where these grasses have not yet occupied the ground or where the soil is shallow and infertile. In wet lowlands, it is encroached upon by Pará grass and Carib grass. In the western and southern parts of the island on extremely shallow soils, especially on mountain slopes where the depth of soil is less than 6 inches, it cannot compete with lamilla. The plant succession following abandonment in such fields is usually redtop millet and Bermuda grass, followed by serrillo, and finally by lamilla.

Although serrillo is not considered to be as palatable as many other pasture grasses, because of the wiry condition of the culms, it is valued by livestock producers as a reliable source of pasturage during periods of extreme drought (fig. 6). The grass also appears to retain its nutritive value for a long time after maturity.

Bermuda grass.—Bermuda grass is a perennial that occurs throughout the island. This grass and a species of sedge known as nutgrass [6] with which it sometimes grows in association are considered to be the two most troublesome weeds in sugarcane, tobacco, and cornfields in Puerto Rico. Bermuda grass recovers more rapidly after tillage than nutgrass and is therefore considered to be the more troublesome of the two weeds.

Where the plants have space for expanding laterally, long creeping stolons that take root at the nodes extend radially from the crown until the entire area is covered, after which the new shoots assume an erect position to produce inflorescenses at the tips. Rhizomes form immediately beneath the surface to several inches below the surface, depending upon the condition of the soil. Although they have a sharp point at the apex, the depth at which they may be found is dependent mainly upon the physical condition of the soil. If the soil is loose and moist they will be found as deep as 6 inches below the surface but if the soil is compact they are found almost immediately beneath the surface.

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[6] SMITH, E. V., and MAYTON, E. L. NUTGRASS ERADICATION STUDIES . . . BY CERTAIN TILLAGE TREATMENTS. Amer. Soc. Agron. Jour. 30: 18–21. 1938.

The grass thrives best in an environment where soils have been disturbed by tillage, road building, excavations, or other operations, and continues to be benefited by the residual effect of tillage long after fields have been abandoned. It is comparatively intolerant to plant competition. Owing to its rapid method of propagation by seeds, stolons, and rhizomes, Bermuda grass finds its way quickly to areas where soils have been disturbed.

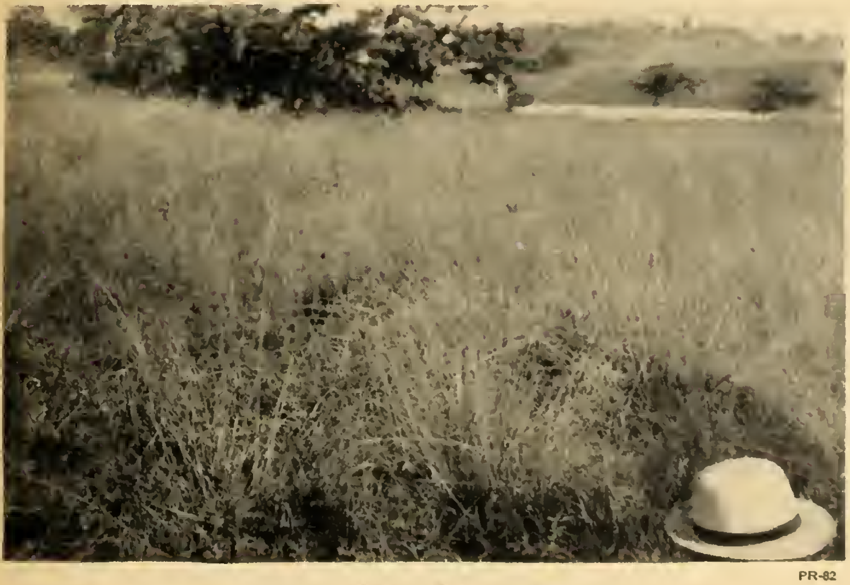

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FIGURE 6.—A good stand of serrillo.

Bermuda grass is seldom propagated for pasture in Puerto Rico. It produces a comparatively dense volunteer growth of forage the first year after the fields have been abandoned, which becomes less in quantity in successive years. The grass is palatable and is relished by livestock, especially by horses.

St. Augustine grass.—St. Augustine grass is found principally on the north side of the island. It forms the most important pasture grass on the shallow soils in the "haystack" hill region. It is a trailing grass that produces stolons sometimes 5 to 10 feet in length. The stolons are comparatively large in diameter. In addition to propagation, they serve also as a source of food supply for the plants during the periods of drought. The species usually grows to a height of approximately 6 inches; but under favorable conditions may reach a height of 20 inches. Owing to its low yield it is seldom planted. The few places where it is planted are on the northeast side of the island, where the soil is too steep and too shallow for tilled crops. The soil is prepared by plowing or by removal of vegetation with a hoe. Sprigs are then set out in rows approximately 2 to 3 feet apart and the same distance apart in the row. These take root and soon cover the entire area.

Tropical carpet grass.—Tropical carpet grass is found in the moist swales throughout the northern part of the island. It is an important constituent of pasture herbage, especially near the western end of the central mountainous region and throughout the lowlands on the north side of the island. It is a short creeping grass that grows to a height of approximately 6 inches. Moisture appears to be the limiting factor that determines its habitat. Seldom planted for pasture it is grazed only where it grows voluntarily. The root system becomes well established in a short time. This characteristic makes carpet grass valuable for controlling erosion and, since it grows in erodible places in draws, it forms a valuable check to soil erosion that would otherwise occur in pastures. Although the grass is not as palatable to livestock as St. Augustine grass, cattle usually keep it grazed close to the ground. It predominates also in the woodland pastures in the interior of the island.

Cintillo.—This is an important pasture grass, not because it is valuable from the feeding standpoint, but because it is so common almost throughout the island. It is found everywhere except in the extremely dry regions on the south and southwest coast, and even here it may be found in low places. It is a stoloniferous grass that covers the ground more quickly than any other species of native grass that is found on the island. It responds readily to tillage, and if fields are abandoned it may completely cover the area and become the dominant grass for a period of several years. It grows to a height of from 10 to 20 inches, depending upon the character of the soil and the amount of moisture. It does not form tufts. It sends out long stolons that take root at the nodes, where it sends up flowering shoots, usually one at a node.

It is never seeded or planted for pasture because its palatability is extremely low. Cattle prefer most of the other common grasses to cintillo. If animals are placed in fields that contain a predominance of this species of grass they graze such other more palatable species as may be available first, and then when they become hungry they take cintillo. Where the stand consists entirely of this species, cattle will graze it in patches. They will return again to these patches to graze the fresh green herbage that has developed and let the ungrazed area go to seed. Animals will eat the plants before they have formed the inflorescences but after that time they shun them.

Lamilla.—Lamilla is found mainly on the dry mountain slopes south and southwest of the divide. It is of considerable economic importance in the areas that are subject to drought, where the soils are too shallow for growing other crops or grasses. The grass develops rapidly during the dry season and then goes into an almost dormant condition during the rainy season. It retains its nutritive value fairly well and is eaten by cattle during the period of drought. The grass is never planted. It is pastured only where it happens to be found.

MINOR PASTURE GRASSES

The following species are listed as minor grasses principally because they occur in less abundance than those listed as major grasses. In addition to these there are other numerous species of lesser importance.

Gamalote (*Panicum maximum*).—This is a native variety that resembles guinea grass. It grows taller than guinea grass and has thicker culms. Its leaves are coarser and it is more subject to leaf spot diseases than guinea grass. Its palatability is also lower. It is found mainly in the north-central part of the island (fig. 7). In sandy regions south and west of Arecibo it sometimes is planted for pasture. Methods of culture are similar to those used for guinea grass. In the places where it is planted on the north side of the island, tuft divisions are set out, and the treatment is similar to that described for guinea grass.

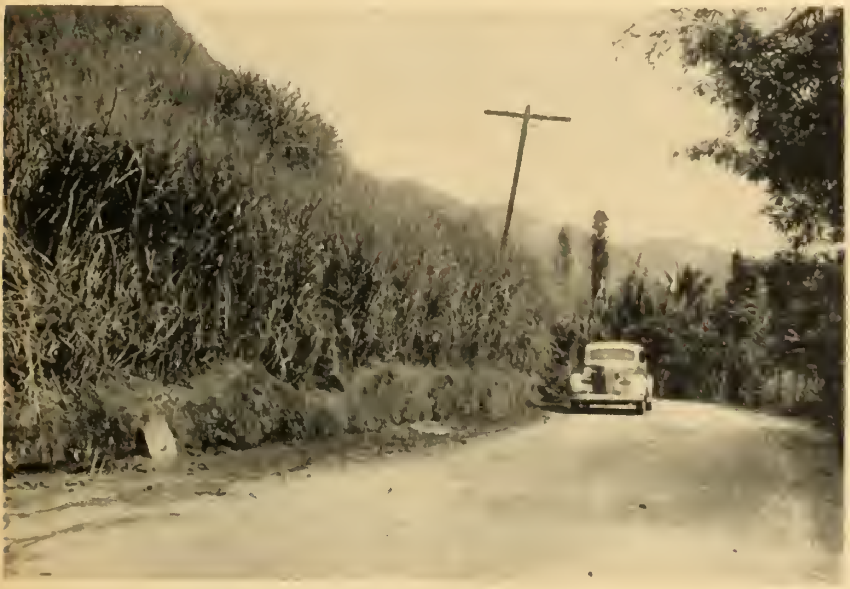

FIGURE 7. Gamalote along a roadside.

Buffel grass.—The species is found only in a limited area in the savanna region on the south side of the island. It grows to a height of approximately 20 inches. Its vegetative parts develop during the rainy season beginning about June. In October the heads appear, and seeds are matured in November. Following that time it becomes almost dormant and resumes its growth again in June. It seems to thrive best on the savanna-land area from Ponce to Salinas and north to the foothills (fig. 8). It grows well, but is not planted for pasture because it cannot compete with guinea grass in yield. It is highly palatable, especially during the early stages of growth. It has a relatively high nutritive value after it enters the mature stage and therefore is eaten by livestock during the period of drought. Farmers consider it an undesirable pasture grass.

Paraguita.—Paraguita is an annual grass that is adapted to situations similar to those that are favorable for the growth of guinea grass. It is found mainly in the southern and southwestern part of the island. It responds quickly to cultivation and occupies the fields in the dry region somewhat as cintillo occupies the field soon after the cultivation in the moister regions. It blooms throughout the year and attains a height of from 20 to 30 inches. It thrives best in a soil that has a slight alkaline reaction. Cattle will eat the young plants before they produce the inflorescense. After that time they will shun them. Farmers look upon paraguita as a weedy grass, and sometimes when there is a small stand among guinea grass they will remove it with a hoe. It is never planted because it cannot compete with serrillo and guinea grass in forage value. It is an annual that occupies fields in the southern part of the island soon after they have been retired from cultivation.

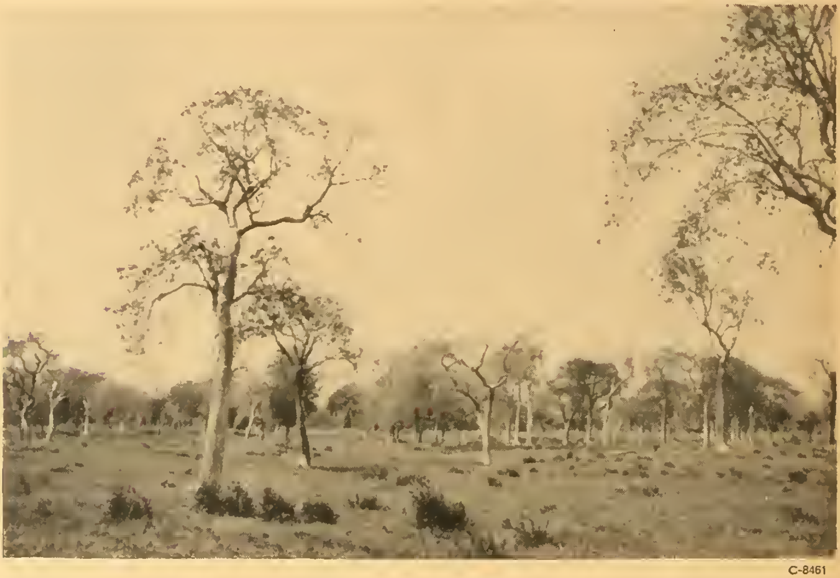

FIGURE 8.—Buffel grass predominates under and among almacigo trees in one of the savanna areas. The tall clumps are guinea grass.

Jamaica fingergrass or pendejuelo.—This grass is found especially throughout the northern half of the island. Its economic importance consists in its value as pasturage during the intercropping period. It is an annual that grows to a height of 10 to 14 inches. It is highly palatable and relished by livestock. It blooms throughout the year depending upon the age of the plant. Sometimes it grows in association with hairy crabgrass (*Digitaria sanguinalis*). It requires a moist, fertile soil and forms one of the first volunteer grasses that comes into the fields as soon as they have been retired from cultivation. It is palatable both in the young and late stages of growth. Its yield is too low, however, to be of any great economic importance as a cultivated pasture crop, because it cannot compete successfully with other species of pasture grasses. Its carrying capacity is limited to approximately 1 to 2 acres per animal for a period of only 1 or 2 months, because after it has once been grazed it will not revegetate as readily as some perennial species. It is one of the transitional grasses in the plant succession.

Redtop millet.—This annual grass is found mainly on the south side of the island and in the sandy region south and west of Arecibo. It responds quickly to cultivation and frequently is found in cultivated fields that have been abandoned. It grows to a height of approximately 12 to 15 inches and produces an abundance of seed. It thrives best where the soils are slightly alkaline in reaction. It tolerates more drought than most of the annual grasses that enter the fields after tillage has been discontinued. It blossoms throughout the year. It is palatable for livestock but, owing to its low yield, is never planted for the purpose of grazing.

Jungle-rice.—Jungle-rice is one of the first species of annual grasses found in comparatively moist areas that have been retired from cultivation. It is a rapid-growing grass that comes into the intertilled fields in low, moist places throughout the island. It is found especially on old sugarcane plantations on the northeastern part of the island. It grows to a height of approximately 14 to 20 inches and produces an abundance of seed. A volunteer grass that grows rapidly, it is highly palatable and cattle relish it, but owing to its low yield and short longevity it is not planted.

Knotgrass (*Paspalum distichum*).—The species is found usually along stream channels and stream bottoms where the water is shallow. It is also found on higher areas where the constant ground-water table is near the surface. It is low in palatability, and cattle will eat it only when there is no other palatable grass in the area. It has a comparatively wide range of tolerance to soil reaction. It reproduces profusely by stolons. The thick creeping stolons grow into erect culms after the ground has been covered.

Bahia grass (*Paspalum notatum*).—This upland grass is found in patches or single spreading plants in pastures in some parts of the island. The short rhizomes turn up to form culms and the plant forms low spreading tufts. The rhizomes in the middle of the tufts of some strains become senescent and discontinue to send up shoots, leaving the vigorous growth only at the periphery of the tuft. Sporadic plants blossom throughout the year. The grass grows to a height of from 8 to 20 inches. It reproduces by both seeds and enlargement of tufts. It is comparatively low in palatability.

Cortadera (*Paspalum millegrana*).—This grass is found especially on the north side of the island. Occasionally it is found on the south side in the depressions where there is much moisture during a short period of the year. The grass appears in tall tufts. It grows to approximately 3 feet in height. On the north side of the island cattle will not eat it if St. Augustine grass or tropical carpet grass are available. However, in the absence of these and similar palatable species, livestock will feed on cortadera. It is never planted in pastures, and its occurrence there is accidental. It has coarsely serrated leaves that make it less desirable for pasture. Although cattle will shun it on the north side where other species are available, they will eat it on the southwestern part of the island at the time when other grasses are in an almost dormant condition. It blooms throughout the year, but its main blooming period is from September to November.

Matojo blanco (*Paspalum virgatum*).—The species resembles cortadera. The leaf edges are not so coarse, and cattle eat it more readily than they eat cortadera. It yields more succulent foliage where it is grazed closely. Some farmers gather the seeds and scatter them in the lowlands in order to increase the density of the pasturage.

Clubhead cutgrass (*Leersia hexandra*).—This grass thrives well in wet swampy places. It appears to be relished by livestock more than most other species of miner pasture grasses. It grows to a height of from 10 to 30 inches and spreads vegetatively by the production of stolons. It requires a moist to wet soil for its best development. Although it is relished by livestock, its yield is insufficient to justify planting it.

Molasses grass (*Melinis minutiflora*).—Molasses grass was introduced on the island about 1923. A few scattered farmers in the central region grow it as a pasture grass. It produces long trailing culms that take the roots at the nodes. After the area is completely covered the culms continue to grow on top of the old vegetation, and sometimes form a deep loose mat of 2 feet or more in thickness. Aerial roots develop from the nodes and extend through this mass to the ground and, after entering the soil, they form roots similar to those that are produced by the plant at its crown or point of origin. The plant does not produce adventitious leaf buds from the nodes of the lignified stems and, if the area is cut, it does not revegetate from the old stubble. The leaves of the plant have a characteristic molasses odor.

When animals first are placed on molasses-grass pasture they do not seem to relish it, but after they are accustomed to it they appear to thrive on it. The roots of the plants are coarse and covered profusely with root hairs. The grass will thrive on a relatively poor soil. It is sometimes planted on fresh banks in road cuts as a preventive measure against soil erosion. Revegetation of areas is accomplished by seeding. The species has a primary blooming period in November and a secondary period in April or May. The seed is collected by hand and dried in the sun. Then it is threshed and stored in a dry place. If it is stored in air-tight drums it will maintain its viability for a period of more than 6 months.

Rabo de zorra.—This is considered to be a weedy grass. It is found in abundance in the mountainous area immediately south of the divide and sporadically throughout the rest of the island. It thrives well in situations where the soil is comparatively moist during, at least, part of the year. It can withstand long periods of drought. The plant grows to a height of 4 to 5 feet. It forms tufts quite unlike those of serrillo and other similar grasses. Nearly all the culms in the open tufts elongate to produce inflorescences. After the culms mature they dry and new shoots are produced from short, thick buds at the crown of the plant. The young leaves and culms of the grass are not relished by livestock. Cattle will eat them, however, after they are mature. It is believed that the leaves have an undesirable taste during the early period of growth, but become more palatable after they have become mature. Rabo de zorra is eaten by livestock during the droughty season.

Diectomis fastigiata.—Although this species of grass is comparatively low in palatability it is eaten by livestock during the droughty period. It is an annual that sometimes grows to a height of 5 feet. It grows rapidly when the moisture supply is adequate. During this period other more palatable grasses are available and, consequently, cattle will shun it. When other grasses are dried up during the droughty period cattle will feed on *Diectomis fastigiata*[7] but they do not thrive well on it. The grass propagates readily by seeds.

Gamelotillo or browntop paspalum (*Paspalum plicatulum*).—This is one of the most palatable native species of the *Paspalum* genera that is found on the island. Its main blooming period is in September. After the seed is mature, the old seed stalks disappear and the plants are characterized by tufts of comparatively succulent leaves. It usually does not last long in heavily grazed pastures because its development is handicapped by preferential grazing of the livestock.

Pajon.—This perennial species is well adapted to dry sites on the south side of the island. The leaves and culms of the grass are succulent and palatable. There is an objectionable odor, however, in the inflorescence. Cattle and horses graze the species readily when the plants are short, but avoid them after they become mature. It responds favorably to the residual effect of tillage, but not as readily as do Bermuda grass and paraguita.

PASTURE LEGUMES

Legumes at present are of minor importance in the pastures of Puerto Rico. Their use in soil conservation practices is confined principally to green-manure and cover crops. Among the legumes that are used for green-manure and cover crops are the *Crotalaria* species (*Crotalaria spectabilis* and *C. striata*), jackbeans (*Canavalia ensiformis*), swordbeans (*Canavalia gladiata*), Florida velvetbeans (*Mucuna deeringiana*), cowpeas (*Vigna sinensis*), and others.[8] Cowpeas are used also for food. The crotalarias and velvetbeans are used as a green-manure and cover crop in the moist areas in the northeastern part of the island. Jackbeans are used in the western part as a green-manure crop. In the northern part swordbeans are used as a smother crop to subdue Bermuda grass in citrus groves. Alfalfa (*Medicago sativa*) has been tested at the Isabella substation. Two cuttings yielded 4.5 tons of hay per acre.[9]

No legumes are planted primarily for pasturage. Although numerous native species are found in old pastures the relative amount of forage that they yield is comparatively low for the following reasons: (1) Many of the legumes in pastures are annuals whose seedlings cannot compete with existing vegetation, especially medium-tall grasses, and (2) the species that are relished by livestock are grazed closely and do not revegetate as readily as native grasses.

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[7] No common name.

[8] KINMAN, C. F. COVER CROPS FOR PORTO RICO. Puerto Rico Agr. Expt Sta Bul 19, 32 pp. 1916.

[9] SERRANO, L. A., and CLAVELL, J. ALFALFA. Puerto Rico Univ. Agr Expt Sta Ann. Rpt. (1937–38): 69 1939.

Among the most common native perennial herbaceous legumes that are grazed by livestock in Puerto Rican pastures are conchita (*Centrosema pubescens*), various species of pega pega (*Desmodium polycarpum*, *D. purpureum* and *D. adscendens*), and zarzabacoa enana (*Stylosanthes hamata*).

Conchita is widely distributed throughout the island. A comparatively dense stand is found sometimes among planted guinea grass on the south side of the island. Although cattle eat the green leaves they do not appear to relish them particularly. The vines creep along the ground. Their growth generally is not heavy enough to produce a good protective covering.

The various species of pega pega are among the most highly palatable species of native pasture legumes. They require a comparatively moist fertile soil that has good subsurface drainage. They are frequently found growing in association with St. Augustine grass and tropical carpet grass. Although these combinations do not produce high yields they are relished by livestock that pasture on them.

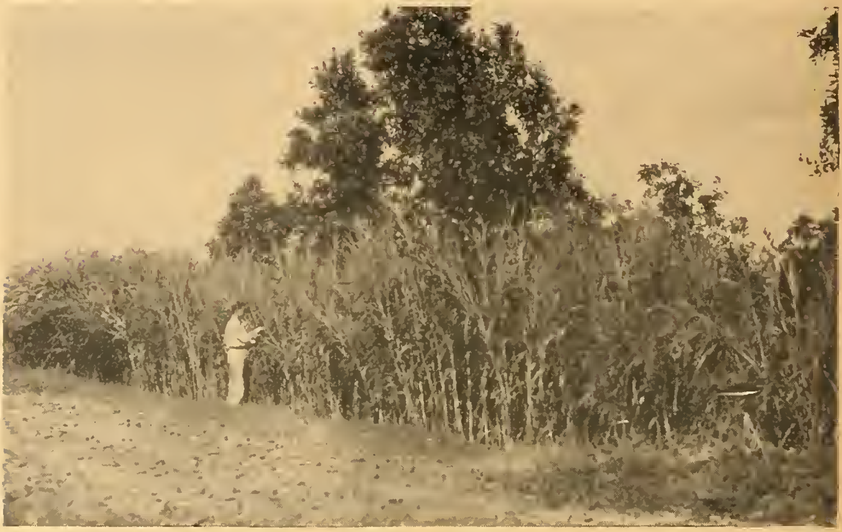

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FIGURE 9.—Elephant grass.

Zarzabacoa enana is a fine-leaved yellow-flowered legume that is found on soils that are subject to severe periodic drought. The plants grow to a height of approximately 6 inches to 2 feet. Old plants sometimes have a taproot approximately an inch or more in diameter at the crown. The leaves of the plants are elongated and resemble those of alfalfa. It is grazed by cattle in pastures where lamilla dominates—a plant with which it frequently grows in association.

There is great need on the island for leguminous plants that can be used for grazing, either alone or in combination with grasses. Little progress has been made so far in finding legumes that can be used profitably for pasturage. The introduction of leguminous pasture plants suitable for grazing in Puerto Rico would greatly enhance pasture development.

Introduced species that appear to be promising both for erosion control and for forage are trailing indigo (*Indigofera endecaphylla*), wild cowpea (*Vigna vexillata*), and blue wandbean (*Calopogonium coeruleum*).

PASTURE SUPPLEMENTS

Supplementary pasture grasses consist of two classes: (1) Those that are planted to be cut for green feed and (2) those that grow wild and are cut wherever they may happen to be found, generally on idle lands and along roadsides. The first class may be subdivided into three groups as follows: (a) Those species that are planted solely for the purpose of cutting and feeding green, (b) those that may be planted for cutting and feeding green, and that may be used also for pasturage, and (c) those that may be planted for cutting and feeding green, and may be used also for grain production.

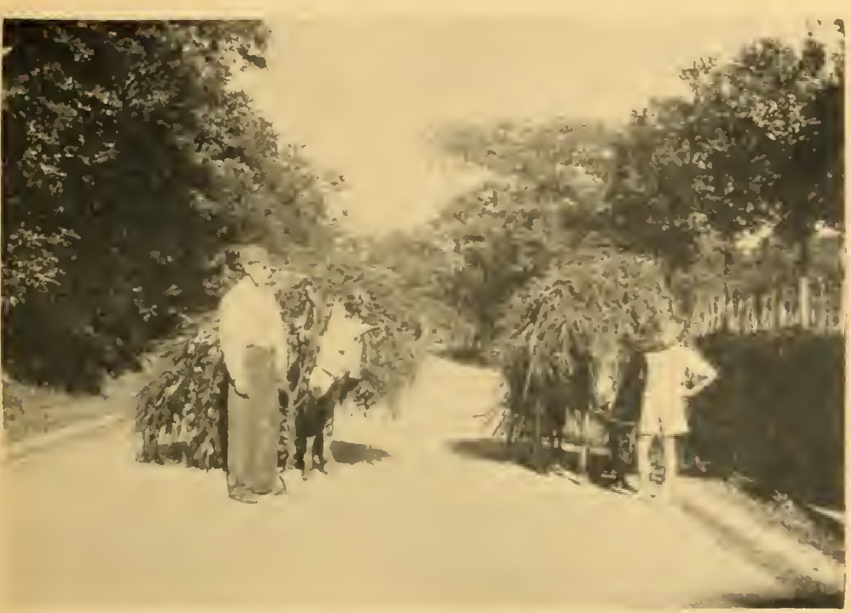
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FIGURE 10.—Donkeys carrying bundles of guinea grass.

Grasses planted only for cutting and feeding green.—Three grasses are used for this purpose: Merker grass (*Pennisetum purpureum*), elephant grass (fig. 9), and Guatemala grass (*Tripsacum laxum*). All of them require a fertile soil with abundant rainfall for their best development. They can be cut from four to six times a year depending upon the stage of maturity at which they are fed. On large farms the soilage is run through an ensilage cutter before feeding. None of these species withstand continuous grazing or trampling.

Grasses planted for cutting and feeding green and for pasturage.—The three species in this group are guinea grass, Carib grass, and Pará grass. They are used principally for feeding pack animals, for dairy cows, and goats that are kept in villages (fig. 10).

Grasses planted for cutting and feeding green and for grain.—The two species in this group are Indian corn (*Zea mays*) and sorghum (*Sorghum vulgare*). Indian corn is planted for forage and for grain throughout the island, although more extensively on the comparatively dry south side, where it is planted during the short rainy season, usually in August and September, and harvested at the beginning of the dry season in December and January. It is believed that greater yields could be obtained in this region if the corn could be planted in March or April, but at that period the soil is deficient in moisture. On the north side of the island the crop is usually planted from February to April.

Yields of this grain are comparatively low throughout the island. It is estimated that they average approximately 10 bushels per acre. although yields as high as 50 bushels per acre have been obtained. The leaves and stalks are fed directly to the cattle or, in the few instances where farmers have silos, they are ensiled. The estimated yield of green forage is 7 tons per acre.

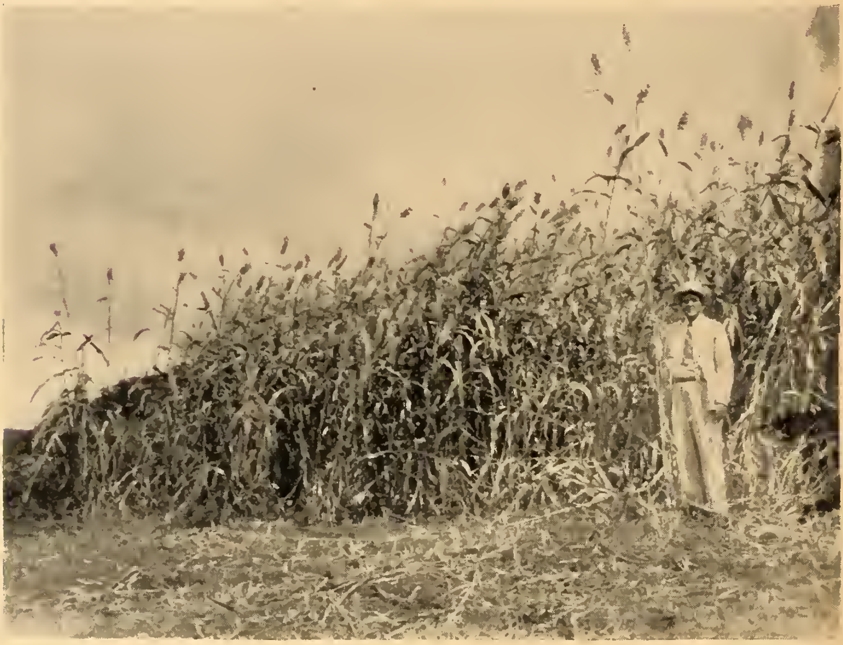

FIGURE 11.—Millo is used for grain and for ensilage.

The production of grain sorghum (fig. 11), known locally as millo (pronounced meel-yo), is limited to the south side of the island. The grain is used for feeding cattle, hogs, and chickens, and for human consumption. The yield is approximately 400 pounds of grain per acre. In the region where farmers have silos, the green forage is run through a feed cutter and ensiled. The yield of silage is from 10 to 18 tons per acre.

Grasses not planted but cut and fed green.—Residents of towns who keep a goat and who cannot afford to purchase feed, frequently search for grasses to be cut and carried home. The most desirable kinds are Carib grass and guinea grass that grow in ungrazed abandoned fields or along roadsides. If these are not available, goosegrass (*Eleusine indica*), gamelotillo, or other species are used. Sometimes the short branches of bamboo plants are cut for their leaves to be fed to cattle in seasons of severe drought.

Sugarcane tops.—During the "zafra" or cane-harvesting season, which usually extends from January to May, oxen that are used for working in the cane fields are fed almost exclusively on cane tops. Some growers construct a temporary electric fence around the harvested area from which the stripped canes have been removed. The leaves and tops are left on the ground. The animals are allowed to run loose and feed on the area. Some cases of bloating have been reported, where hungry animals have been allowed to feed on fresh-cut areas. If green cane tops exclusively are fed to dairy stock they are said to impart an objectional flavor to milk that is produced by the animals.

Silage.—The use of silage is limited to a small area of the island in the regions of Coamo, Salinas, and Ponce. Approximately a dozen silos are in active use. The tower silos are cylindrical in shape, approximately 15 feet in diameter and 35 feet high (fig. 12). The pit silos that have been built have approximately the same capacity. Although the best silage is obtained from Indian corn, sorghum is used by a number of farmers, because much higher yields are obtained from the latter. The green corn and sorghum are ensiled in a manner similar to that employed in the States. After the crop has been ensiled for 6 weeks or longer it is ready for feeding. Silage is used as a supplemental feed principally during the dry period of the year, which occurs usually from January to May. A few silos have been built in other parts of the island, but these have been abandoned. Most farmers prefer to cut the feed green and feed it directly to livestock.

Hay.—The amount of hay that is made on the island is negligible. Although there are seasons of drought when the supply of forage in pastures is low, cattle can be pastured throughout the year. Farmers do not possess hay-making implements. The primitive method of plowing usually leaves the surface too rough for the use of harvesting machinery. Also, oxen are too slow to be used in drawing mowing machines. Nearly all grasses are harvested with machetes.

In the humid sections of the island it would be difficult to cure the hay without its deteriorating. Frequent light showers occur during the periods when the grasses are ready for harvesting for hay. Because Carib grass and Pará grass have thick culms, it would take a long time to cure these grasses. No barns are available for storing hay, although shelters similar to those that are erected for curing tobacco could be used.

Also there are few grasses that are suitable for hay making. Guinea grass occasionally has been made into hay on sugarcane plantations on the south side of the island. The yield of the first cutting was from 1 to 2 tons of hay per acre. It is estimated that the average annual yield would be from 4 to 6 tons per acre. The hay is fed to horses that are ridden by overseers. It is relished by horses and could be used more extensively. Other experiments in hay making have been conducted at the Isabela Branch Agricultural Experiment Station. Both guinea grass and serrillo retain their nutritive values reasonably well on the stand in pastures during the drought period, and it is not economically profitable to employ labor for making hay when cattle can eat the mature grass directly from the field.

Concentrates.—Most of the concentrates that are used are fed to dairy stock. A limited quantity of Indian corn and sorghum is produced in Puerto Rico and fed on the farms. Molasses is fed to dairy animals and horses with guinea grass and Pará grass that have been run through an ensilage cutter. Some farmers feed roots of the cassava and sweetpotatoes to dairy cattle. Concentrates that have been compounded commercially are imported. During the fiscal year 1939–40 approximately 52,000 tons of mixed dairy and poultry feeds and 3,000 tons of other concentrated feeds including bran and middlings were imported from the United States. During the same period approximately 1,000 tons of bran, middlings, and other wheat by-product feeds were imported from foreign countries.

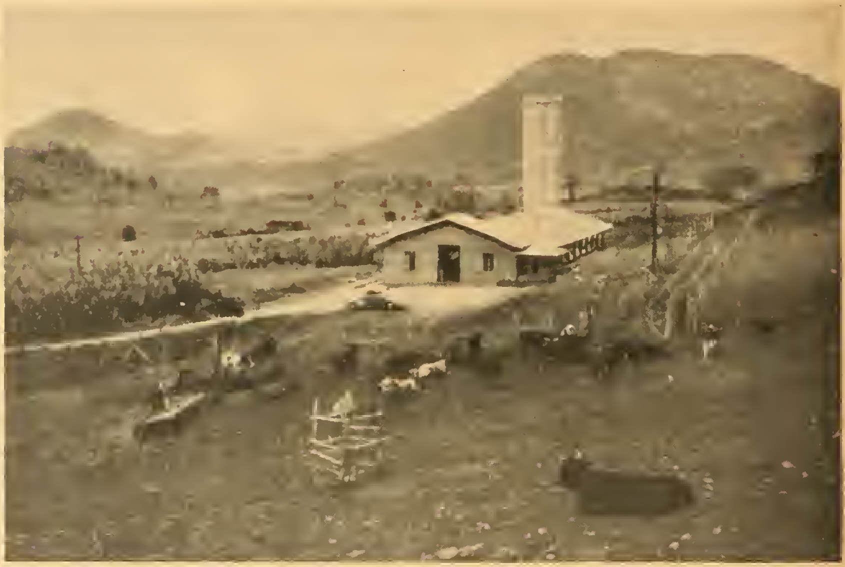
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FIGURE 12.—Milking shed and silo.

PASTURE WEEDS

Plants that are undesirable in pastures are classed as weeds. The line of cleavage between the weeds and desirable herbage is not sharp. Animals graze the most palatable species first and as the feed becomes more scarce they gradually feed on the less palatable ones. Weedy plants in Puerto Rican pastures may be grouped as follows: (1) Relatively palatable but unproductive plants, (2) those plants that are relatively low in degree of palatability, (3) plants that are thorny or spiny or that may have other objectionable features.

Relatively palatable but unproductive plants.—Although these species of plants may be numerous on idle lands their stand is reduced rapidly by selective grazing. In overgrazed pastures they soon succumb.

Blero blanco or algondoncillo (*Amaranthus viridis*) is an annual weed, with oval leaves and green flowers borne in spikes. This is a troublesome weed in pastures and cultivated fields, but is eaten by livestock, especially by horses and poultry. The roots are sometimes used for medicinal purposes.

Margarita silvestre (*Bidens cynapiifolia*) is an annual plant with quadrangular, erect stems and succulent leaves. The flower heads have five white rays and a yellow center. Although considered a weed by farmers, it is eaten by livestock and constitutes a fair pasture herbage during dry spells along the hilly uplands of the coast. Sometimes it is used for medicinal purposes.

Bejuco de puerco species (*Ipomoea setifera and I. tiliacea*) are spreading, aggressive vine weeds that grow on common pastures and along fences and posts. They are relished, especially by pigs and rabbits.

Malva silvestre (*Malvastrum spicatum.*)—This is a common weed that is found almost throughout the island. Cattle do not eat it when such species of grasses as guinea grass, serrillo, lamilla, and others are available. They prefer it, however, to cintillo.

Plants that are relatively low in degree of palatability.—These species of plants are usually found in pastures that have been managed poorly or where little or no attention is given to their maintenance and improvement. Pastures in which these weeds occur in abundance can usually be improved by plowing and then planting to guinea grass.

Zacaton, rabo de gato or foxtail (*Andropogon bicornis*) is eaten by livestock when it is young, but cattle will avoid it after it has produced culms that bear the inflorescences. Some farmers remove the tufts completely with a hoe, while others cut the tops only with a machete in order that new growth that is more palatable shall develop.

Yerba de cabrio or tropic ageratum (*Ageratum conyzoides*) is found in abundance in pastures at elevations above 1,000 feet. The weed is subdued by frequent cuttings with machete. If it is left unmolested it will possess the entire field where it thrives.

Blero colorado or bloodflower milkweed (*Amaranthus dubius*) is similar to the blero espinoso, except for the absence of spines. Eaten to a limited extent by livestock.

Blero espinoso or spiny amaranthus (*Amaranthus spinosus*) is similar to the white and red bleros, except that it grows more erect and bears two spines in the axil of the rhomboid lanceolated leaves. This is an undesirable weed in pastures and cultivated fields, although it is eaten to a limited extent by livestock.

Ajenjo or common wormwood (*Artemisia absinthium*) is a common weed, especially on recently abandoned fields in the southwestern part of the island. Sometimes the stand of this species is very dense.

Clavelillo or railway beggarticks (*Bidens pilosa*) constitutes one of the worst pasture weeds of the island. It spreads by long runners and underground stems and is difficult to eradicate. Where this plant grows, which usually is among pasture grasses under moist conditions, it continues to spread until it kills all grasses and other low-growing herbage. It constitutes a pest in sugarcane fields as well as in pastures. It is seldom eaten by livestock.

Botoncillo (*Borreria verticillata*) is a troublesome weed in pastures at low and middle elevations where the plants have been allowed to grow for a long time. It is a perennial, erect, shrubby plant, growing from 21 to 26 inches tall with linear lanceolate leaves and white flowers in the shape of a button. It is eaten by livestock. It is host plant for the beneficial wasp *Larra americana*, which is a parasite on changas or mole crickets.

Hedionda or coffee senna (*Cassia occidentalis*) is a shrubby perennial legume that is sometimes cultivated for its seeds, which are used as a substitute for coffee by the natives. It grows from 3 to 5 feet tall with weedy stems and lateral branches. It is considered a pasture weed on those fields where this legume had been previously cultivated, and near the country houses and "bohios" where generally a patch is grown for home use. It is not eaten by livestock. It occupies the ground completely after it has once become established. This plant is sometimes grown commercially in the region near Quebradillas, Isabela, and Aguadilla.

Dormidera or sickle senna (*Cassia tora*) is a herbaceous annual legume with a maximum height of 3 feet that becomes an obnoxious weed in fields that have been cultivated and recently abandoned to volunteer pasture herbage. The seeds are numerous and viable and germinate during the beginning of the rainy seasons in May and October. If the seedlings are not removed before the new seed crop is mature, the field will soon become seriously infested with this weed. The plant is not eaten by livestock.

Anil or indigo (*Indigofera suffruticosa*), one of the worst shrubby weeds in the pastures of the coastal plains, escaped from indigo plantations about a century ago. It is a perennial legume, which grows to over 5 feet in height with branches extending to about 2 feet laterally. It is eaten to a limited extent by livestock when it is young. As soon as it reaches maturity, its branches become woody. At this stage it is seldom eaten by livestock. If the stems are cut close to the ground, and the stumps are not uprooted, they will recover and new shoots will grow again. Where this plant predominates few species of other plants grow under its shade.

Molinillo (*Leonotis nepetaefolia*) is an annual or biennial weed with erect stems and oval leaves. Grows several feet tall in thick stands in the pastures. The leaves have a bitter taste, and are very unpalatable to livestock. It is troublesome in pastures and cultivated fields.

Cundeamor or balsam pea (*Momordica charantia*), a climbing vine, becomes a troublesome weed only during the beginning of the rainy season when it climbs and covers the desirable pasture plants. However, due to its delicate growth, it is destroyed easily by grazing livestock. It is most commonly found climbing on wire fences and along borders of maya plants, where it is not disturbed by livestock.

Taguatagua or tagua passiflora (*Passiflora foetida*), an herbaceous trailing weed, grows to approximately 10 feet in length. It occurs on hillsides, waste, and cultivated grounds at low and middle elevations, but is not eaten by livestock and constitutes a troublesome weed on hillside pastures.

Guayaba or common guava (*Psidium guajava*), a woody shrub or small tree found mainly in the vicinity of buildings and in abandoned fields. It produces fruits periform in shape that are used in making jelly. The leaves are sometimes used by natives for medicinal purposes. It propagates readily by seed in old pastures and abandoned lands.

Rabo de zorra, a grass, is shunned by livestock on account of its low palatability. It thrives on soil that is relatively fertile. The grass is tolerant to seasonal droughts. Farmers frequently remove it with a hoe in order to make room for more productive species.

Cadillo (*Urena lobata*) is a shrubby perennial weed with wide, deep-green leaves. It grows over 6 feet tall. It seeds profusely. The resultant seedings frequently cover entire fields in a relatively short period. Cattle eat the leaves of the young plant when no more palatable herbage is available, especially in overgrazed pastures. In order to eradicate the plants the roots must also be removed, otherwise new shoots will emerge rapidly from the stubble. If the seeds are allowed to mature, the new seedlings will soon make a thick growth crowding out other more desirable plants.

Verbena or Jamaica false valerian (*Stachytarpheta jamaicensis*) occurs in open pasture fields that are poorly managed. It is not eaten by livestock and is a troublesome pasture weed, especially on sandy loams and sandy soils on the coastal plains. It is used for medicinal purposes by the natives.

Santa Maria (*Vernonia albicaulis*).—The stems and leaves have a strong odor when they are crushed. The species is not eaten by cattle, but goats browse on it. In some places in the southwestern part of the island this species has taken possession of entire pasture fields. Its growth is reduced by cutting with machetes two or three times a year.

Plants that are thorny or spiny or otherwise objectionable.—Thorny and brambly plants are avoided by livestock. Where they occur in pasture lands that are given no care the areas soon revert to brush land and become of little value for grazing.

Maya or pinguin bromelia (*Bromelia pinguin*) is a spiny plant sometimes used for fencing pastures. It forms a thick barrier that is avoided by animals due to the many recurved spines found on the margin of the leaves. It grows from 2 to 4 feet tall. It produces suckers that spread laterally into the adjacent areas.

Pazote or wormseed goosefoot (*Chenopodium ambrosioides*), an annual, erect plant, which when eaten by dairy cows imparts a distasteful flavor to the milk.

Zarza (*Lomopilis ceratonia*) is a shrubby, brambly vine with many small thorns on its stems. It is a bad pest in pastures. Where the stand is dense it is almost impossible for man or beast to go through the area without being scratched severely by the thorny brambles.

Dillen prickly pear or cactus (*Opuntia dillenii*), the common cactus, is found mainly on the south side of the island. It is sometimes a troublesome weed, especially where the soil is sandy.

Anamu or garlic guinea-hen weed (*Petiveria alliacea*) is abundant in the coffee area where it grows under partial shade, and in thickets and woodlands along the coast. If the foliage of this plant is eaten by cows, it imparts a garlicky flavor to the milk.

Morivivi (*Mimosa pudica*) is found in old pastures throughout the humid regions of the island. This species is a sensitive plant that folds up its leaves as soon as animals touch it. The stems are thorny. Cattle will not eat the plants if grasses are available.

WATER SUPPLY FOR LIVESTOCK ON PASTURE

One of the features of a good pasture is an abundant supply of drinking water for grazing animals. In Puerto Rico the water for pasture animals is supplied from wells, cisterns, streams, ponds, irrigation water, or city water.

Most of the water is supplied by wells that are dug or drilled. The dug wells generally are shallow, not more than 20 to 30 feet in depth. They are found usually in the coastal region. Some of the wells even in this region are drilled. The depth of the drilled wells ranges from 50 to 200 feet. In some sections the water is obtained from rain that falls on the roofs of buildings and is stored in huge cisterns. Where the soil is impervious, some farmers have been able to utilize water that was collected in charcas or ponds. In some places on the south side of the island the cattle obtain their water for drinking from irrigation viaducts, which may run through or adjacent to the area. Where farms are located near cities, the water for the livestock is obtained from the city water supply. The percentage of farmers that use city water for their livestock is comparatively small. There are a few natural springs in some of the pastures of the island.

RELATIVE PALATABILITY OF PASTURE HERBAGE

The factors that are involved in the relative palatability of pasture herbage are inherent in both the grazing animals and in the herbage. In many instances a distinct line of cleavage among the factors cannot be drawn. In general, the factors that are inherent in the grazing animals are the olfactory, gustatory, and tactual senses, the class and age of the grazing animals, the degree of hunger, and the class of forage to which the animals have been accustomed. The factors that are inherent in the herbage are species characteristics and age of plants.

Olfactory factors.—Animals avoid grazing some species that have an objectionable odor or that grow in close proximity to an odor arising from other causes. The leaves of some species of *Eragrostis* and the inflorescences of some species of *Andropogon*, such as hurrican grass (*Andropogon pertusus*) and pajon have an odor that is disagreeable to livestock, and, therefore, the animals shun them. They will also avoid grazing near animal dung, especially that of their own class, probably due to an instinct to avoid intestinal parasitic infection.

Gustatory factors.—The sense of taste of the animals plays an important role. Cattle will eat now and then of any herbage that may be found in pastures. The animals soon learn to recognize the species they relish. Some grasses have a very disagreeable taste. For example, the taste of lemon grass (*Cymbopogon citratus*) is bitter, that of hurricane grass is musty, and that of Barbados sourgrass (*Andropogon intermedius var. acidulus*) resembles the taste of the anise plant. At the other extreme are such species as St. Augustine grass, guinea grass, and pink clubhead cutgrass which are relished by all kinds of grazing animals.

Tactual factors.—Cattle will avoid plants that are painful to the sense of touch. This is particularly the case where the herbage is spiny or has thorns such as Dillen prickly pear or morivivi. Cattle relish abrojo before the spiny involucres have formed.

Class and age of animals.—Some species of herbage are relished by one class of livestock and to a lesser degree by another class. In pastures where both guinea grass and Bermuda grass are found in close proximity, cattle seem to prefer the guinea grass, while horses prefer Bermuda grass. Goats are not as particular in the choice of herbage, and often are found browsing on weeds that are shunned by horses and cattle. Hogs and rabbits prefer species of bejuco de puerco to grasses. Young animals show a greater preference for succulent herbage than do older animals.

Degree of hunger.—Hungry animals are not as particular in their selection of species of herbage as animals that have been well fed. On the north side of the island, where the seasons of drought are not so prolonged, cattle graze sparingly on such species as cortadera, while on the south side of the island they seem to relish this species. Also animals that are transferred from a droughty region, where all herbage is dry will graze on almost any green grass immediately after having been transferred to green pastures.

Previous pasturage.—Animals that are accustomed to one type of forage in a pasture sometimes do not relish certain species of grasses or other herbage in new pastures, until they become accustomed to feeding on them. For example, if cattle are transferred from pasturage consisting of native grasses to molasses grass, the animals graze sparingly for the first few days. After they become accustomed to it they thrive on it.

Species of grasses.—There are wide variations in the palatability of the various species of pasture grasses. Numerous observations have been made on the degree of preference by the animal in various parts of the island. On the north side of the island the preference for the principal native pasture grasses has been found to be in the following descending order: guinea grass, clubhead cutgrass, St. Augustine grass, Carib grass, Pará grass, tropical carpet grass, serrillo, and cintillo. In all of the lowland pastures, cattle graze the patches of clubhead cutgrass close to the ground before the other grasses are eaten. Cintillo ranks lowest in palatability.

In the southwestern part of the island, planted guinea grass is preferred. The palatability of the native grasses in this region is in the following descending order: Serrillo, lamilla, paragnita, and pajon. Horses, however, seem to prefer pajon, before it heads, over the other native species in this region.

In almost all species of grasses the young succulent stage of the herbage is more palatable than the more advanced stages of growth.

Cattle will eat the young basal leaves of zacaton but will not eat the seed-bearing culms.

Although a high degree of palatability is desirable in grasses, it does not necessarily determine their comparative economic value. St. Augustine grass is a highly palatable grass but its yield is too low to justify planting it on lands where Carib grass and Pará grass can be grown. Likewise, Bermuda grass is more palatable than some native species like cintillo and others, but its use as a permanent pasture on the north side of the island is not recommended because it is soon crowded out by native volunteer species.

Some species are so low in palatability that cattle will not eat them unless they are extremely hungry. These include zacaton, yellowsedge beardgrass (*Andropogon virginicus*), pajon hembra (*Andropogon gracilis*), rabo de zorra, and pachuli (*Vetiveria zizanioides*.) Other species are so unpalatable that cattle will eat them only when they are almost at the verge of starvation. Among the species are mellito (*Sorghastrum setosum*), lemon grass, and wiregrass (*Uniola virgata*).

Another desirable quality in pasture grasses is their retention of a comparatively high degree of palatability in the mature stage, such as is possessed by guinea grass, serrillo, and buffel grass. Although the growth of these species is almost at a standstill during the period of drought, the amount of forage that was produced during the wet period in excess of that which was needed by the grazing animals remains to be utilized as pasturage during the dry period.

A high degree of palatability is frequently not a desirable characteristic of a grass that is to be used primarily for erosion control. This is particularly the case where grasses are used to protect the sides of road fills. Stray cattle are tempted to climb up the steep banks to graze the palatable grasses that are growing in the soil on steep slopes and spoil the fills by their tramping. If such species as pachuli, lemon grass, wild cane, or Uva grass (*Gynerium sagittatum*), or other species that are low in palatability are planted, cattle will stay off the critical slopes.

ESTABLISHMENT OF PASTURES

Three methods are used in establishing pastures: (1) Cultivated fields are abandoned and allowed to grow up to volunteer vegetation, (2) grass is seeded in corn just before the last cultivation, or (3) the land is prepared by plowing and harrowing and is then seeded or planted with the definite intention of establishing a pasture.

Abandonment of cultivated fields.—Tilled lands that are abandoned are soon covered with vegetation, most of which consists of various species of grasses. There are several stages of succession of species, with one stage gradually merging into the next. For example, on the north side of the island the first stage occurs during the last months of the cropping period, before the crop is harvested. It is characterized by the appearance of short-lived annuals, consisting mainly of red sprangletop (*Leptochloa filiformis*), jungle-rice, and Louisiana cupgrass (*Eriochloa punctata*). After the crop has been harvested the second stage appears; its main species are Jamaica fingergrass, goosegrass, and sometimes knotroot bristlegrass (*Setaria geniculata*). The third stage appears about 2 or 3 months after harvesting and is characterized by the presence of cintillo, tropical carpet grass, and zacaton. The fourth stage, which appears several years after abandonment, is characterized by the dominance of serrillo, St. Augustine grass, and Bahia grass. Grazing plays an important part in the succession, for it retards development of the palatable species and aids that of the less palatable.

In some sections on the south side of the island the first stage of succession consists of redtop millet. The intermediate stages consist mainly of gazon, crowfoot grass (*Dactyloctenium aegyptium*), and serrillo. The final stage, as found in old pastures, consists of serrillo, pajon, and lamilla, with the last-named species predominating. During the first year after abandonment, Bermuda grass forms a considerable part of the herbage where the fields were infested with it before abandonment.

Seeding grasses in corn.—A common method of establishing pastures on the south side of the island is by seeding guinea grass in corn just before the last cultivation of the crop. The threshed seed is sown on top of the ground at the rate of 50 to 100 pounds per acre, or an equivalent amount is sown by broadcasting the panicles containing the seed. Cultivation buries the seed and as soon as there is sufficient soil moisture, the seeds germinate. Seeding is done from May to September.

Plowing, seeding, and planting.—The land is plowed after the cultivated crop has been removed. After the seedbed is in condition for seeding, the seeds are broadcasted. The rate of seeding guinea grass is usually from 100 to 125 pounds per acre. Molasses grass is seeded at the rate of from 5 to 10 pounds per acre. The high rate of seeding of guinea grass is necessary because the rate of germination is usually comparatively low. The land is reharrowed after seeding. If the soil is moist, most of the seed will germinate, but if it is comparatively dry, the germination will be sporadic. Seeded pastures are ready for grazing approximately 4 months from the time of planting, depending upon the rainfall during this period.

Some pastures are established by planting tufts (fig. 13). The preparation of the seedbed is similar to that of seeded pastures. Tufts of guinea grass or gamalote are set in rows approximately 2½ feet apart and 2½ feet apart in the row. The space among the plants is cultivated or hoed until the inflorescence is formed. The field is then laid by and the interspaces are seeded by self-sowing of shattered seeds from established plants. In general, guinea-grass pastures on coastal areas of the south side are established by seeding, while in the region of Arecibo and in the mountainous area on the south side of the divide, the planting of tufts is practiced.

Areas that are prepared for planting Carib grass and Pará grass are treated similarly to those for guinea grass. Seeds of these species of grasses are never sown. Long parallel trenches or furrows approximately 4 to 6 inches deep and 2½ feet apart are made across the field. Planting should be done when the soil is moist. Culms of from 2 to 4 feet in length are laid in the trenches, so that the tips will be on the ridges and the remainder in the trenches. The part in the trenches is then covered with soil. Sometimes the cuttings are planted by laying them in the furrows at the time of plowing. Owing to their trailing habit, these grasses soon cover the area. After the area is covered completely, trailing ceases, and only erect culms are produced. The area is usually ready for pasture about 3 months from the time of planting.

St. Augustine grass is planted, sometimes, for pasture on shallow soils underlain with limestone on the north side of the island. The preparation of the seedbed and the planting is similar to that for Carib grass and Pará grass. The culms that are placed in the shallow trenches are shorter. The method is similar to setting sprigs. The area planted to St. Augustine grass is ready for pasturing from 3 to 6 months after planting.

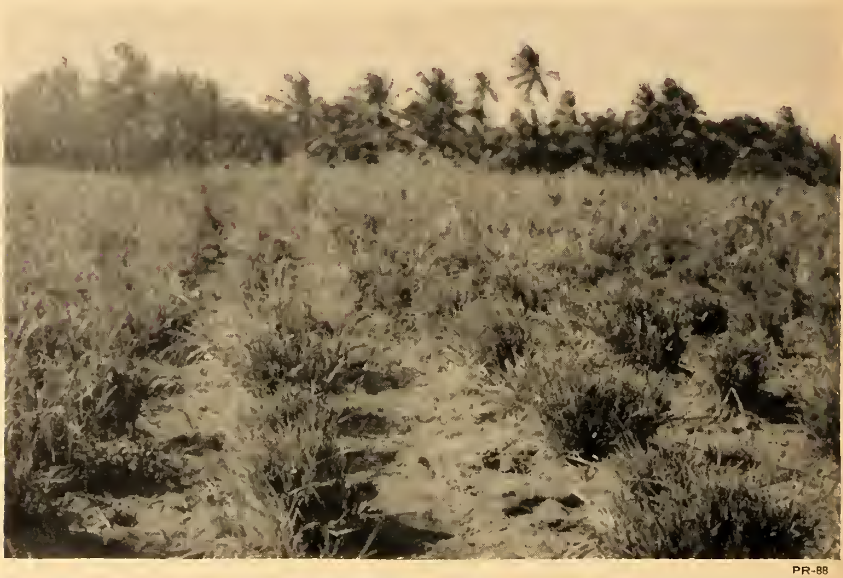
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Figure 13.—Planted guinea grass.

PASTURE MANAGEMENT

Little attention is given to management of temporary pastures or pastures that are used mainly as an exercising lot for cattle that are provided with such supplementary feeds as soilage, cane tops, or silage. On the other hand, many permanent pastures upon which cattle are wholly dependent for feed over a period of years are managed economically and systematically.

Temporary pastures consist usually of fields of volunteer grasses that are grazed during the intercropping period. The farmer will graze as many head of cattle as he has, and when the forage is exhausted he will find some other area on which to graze. Also, little attention is given generally to the management of pastures that result from lands that are left idle after they are too poor for cropping. After a good stand of various species of native grasses has been established, provided the area is not overgrazed, the period of fair to good pasturage can be prolonged.

The degree of grazing is controlled by limiting the number of head of livestock per unit area, so that there will be an adequate amount of grass during the dry season. Where animals are given the entire area from the beginning there is a tendency for the pasture to become patchy. A number of species of grasses are found in the pastures. Animals graze the most palatable species first, allowing the less palatable ones to mature. They return to the grazed portions and prefer the new succulent growth. On the north side of the island, where the volunteer stand in some pastures consists primarily of cintillo, the animals graze a small patch here and there. After a few days they return to the same patches to graze the new growth, allowing the remainder of the grass on the ungrazed portions to become fibrous and comparatively unpalatable. Also, cattle will avoid grazing near animal droppings, permitting the grasses near them to mature. If occasional weeds like morivivi are present, cattle will not graze the immediately adjacent areas. Patchiness in pastures is reduced by rotational grazing, allowing the animals to graze the area clean before moving them to the next enclosure. The enclosures are fenced with barbed wire that is shipped from the States and posts that are made from native trees.

Management of the guinea-grass pastures.—The pasture land on well-managed farms is divided into cercados or enclosures each consisting on an average of approximately 15 acres. The number of acres in a cercado varies with the size of the farm. Some of them consist of as low as 5 acres, while others run as high as 100 acres. The cercados vary in size also on individual farms. Cattle are grazed in one cercado and, when the feed becomes short, they are moved successively to the next ones until all have been grazed, after which they are moved to the first, and then the cycle is repeated. The grazing period in each cercado usually is from 3 to 8 weeks, followed by a similar rest period, depending upon the condition of the grass and the judgment of the farmer.

In the region near Arecibo, farmers tether their animals on guinea-grass pasture. Stakes are driven into the ground and cattle are tied to them by ropes varying from 15 to 25 feet in length. The stakes are reset by the herdsman to adjacent areas from 2 to 4 times a day. The animals are returned to the same areas after a period of from 4 to 8 weeks.

Management of Carib-grass and Pará-grass pastures.—These pastures usually contain a mixture of these grasses. They are found mainly in the northeastern part of the island. Where they have been planted on the uplands, the pasture management is similar to that of guinea-grass areas. In the lowlands, where they form the natural dominating ground cover, they are grazed only during the dry period. When the ground is saturated with water during the rainy season, the grass is cut and fed green on upland enclosures.

PASTURE IMPROVEMENT

Resting pasture lands.—Overgrazed pasture lands can be improved by taking cattle off the area for a period of 6 months or longer and allowing the stand of grass to thicken. It gives the species of palatable grass an opportunity to recover (fig. 14).

Seeding.—Some farmers on the north side of the island scatter seeds in old pastures to improve the grazing. Seeds of matojo blanco are collected by hand and scattered in places where the stand of native grasses is thin, and in the depressions where the seed is most likely to germinate. On the south side of the island, guinea grass and serrillo are seeded in old pastures after they are weeded. Seeds are scattered in places where the soil has been disturbed with machete or hoe in the process of removing the weeds.

Planting.—In the savanna region and also in the woodland pastures on the mountain sides, the native pastures are improved by planting small tufts of guinea grass. Where ox-drawn plows can be used, furrows are made at 2- to 5-feet intervals on the contour, and the tufts are then planted in the furrows. Where the land is too steep for the use of oxen, holes are made with a hoe or pick mattock and the tufts are set in the holes.

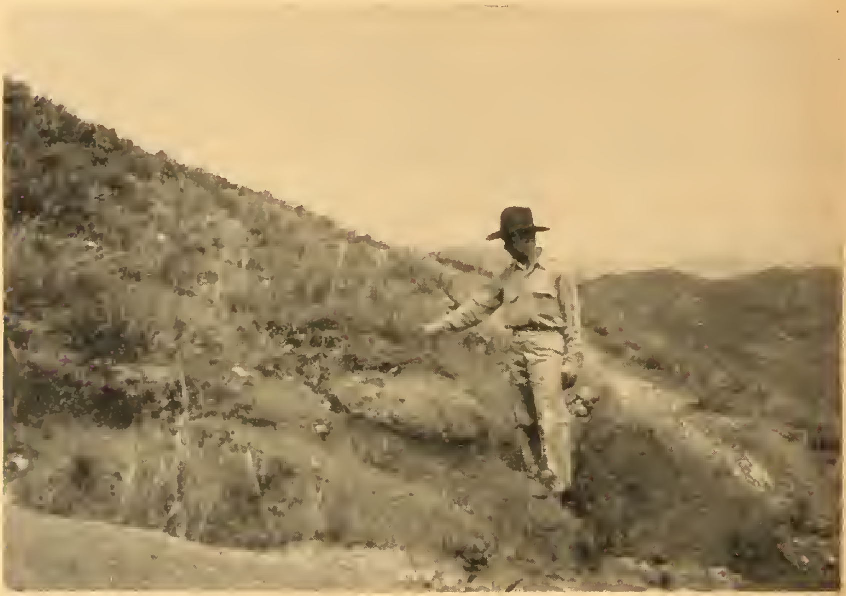
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Figure 14.—Overgrazed pastures are subjected to severe erosion. This pasture was rested after the damage had been done.

Intertillage.—Intertillage is practiced in the guinea-grass areas on the south and northwest sides of the island, and in the region where Carib grass and Pará grass are grown on the northeast side of the island. In the guinea-grass area on the south side of the island the intertillage is accomplished by plowing on the contour of the hills with a primitive plow, so that sometimes the large vigorous tufts of guinea grass are disturbed but little. Some of the lateral roots are torn, but the greater portion of the tufts remain in place. Guinea grass or serrillo is then seeded in the freshly disturbed areas. In the sandy area on the north side of the island, guinea grass and gamalote are planted in rows, and the interrow area is plowed to aerate the soil and to control weeds.

On the north side of the island, in low wet lands subject to floods, the fields that have a stand of Carib grass and Pará grass are tilled by plowing on an average of once in every 3 years. Plowing is done by oxteam. The work that is done is comparatively crude, and the grass is not covered completely. Enough plants remain uncovered to revegetate the area without replanting. No seeds are sown. Due to the trailing habit of the grass culms of these species, entire areas are covered again with a luxuriant growth of grasses within 3 to 8 weeks after plowing. In some instances the grass is used mainly for cutting and feeding as soilage.

Weeding.—Old pastures are weeded once or twice a year. The undesirable species of plants, such as morivivi and many others, are removed with a machete or hoe. Little seed, other than matojo blanco, is sown on the north side of the island, while in the southwestern part, where the weeding of old pastures is usually done immediately following intertillage, guinea grass and serrillo seeds are sown.

Plowing grasslands.—Grasslands are plowed by progressive stockmen and dairy men in Puerto Rico. Although the general method is the same, there are some variations in the different parts of the island due principally to differences in soils and precipitation. The main regions where plowing is practiced are on the heavier types of soils in the northeastern part of the island, where Pará grass and Carib grass are cultivated for green forage and pasturage; in the northwest central sandy region of the island, where gamalote and guinea grass are grown; and in the southern and western parts of the island, where guinea grass is grown.

Livestock producers have found that lands cannot be pastured continuously without reducing the yields to the point where they are no longer economically productive. If nothing is done to the pastures they soon become sod bound or the old crowns of tuft-forming species become senescent. The roots and crowns become numerous but not active. They continue to function slowly and retain only enough activity to remain alive. Plowing the land aerates the soils and forms a more favorable environment for the young growing plants. In the case of Carib-grass pasture the old roots are torn up, and, together with the old portions of culms and leaves above the ground, they begin to decay, forming a fresh food supply for young growing plants. Some farmers plant other crops in rotation with grasses, while others continue to grow grasses in the same fields year after year.

In the eastern part of the island the grasslands that are plowed constitute the uplands that are planted to Carib grass and Pará grass. The old roots and tops become senescent and produce little forage. The land is plowed as thoroughly as possible after having been in grass for about 3 years, and then it is planted to sugarcane or some other crop before it is replanted to pasture grasses. The sugarcane crop is fertilized, and the pasture grasses that follow the sugarcane in rotation are influenced in their growth by the residual effect of the fertilizer. In the lowlands that are too wet for growing sugarcane, or that are subject to severe erosion at the flood stage of adjacent streams, the land is plowed once every 3 years during the dry season. No grass is planted. Enough volunteer plants of Carib grass and Pará grass reappear completely to revegetate the area.

In the northwest sandy region of the island the grasslands that are plowed consist of gamalote and guinea grass. These lands have a considerable periodic supply of moisture from precipitation, but are subject to severe drought because the soil is sandy. Grasses are planted in rotation with corn, beans, and sometimes sugarcane. The first year after the grasses have been planted a large yield of forage is obtained, which is considerably less the second year, and after the third year the yield is too low to be profitable. The fields are then plowed again, and sometimes are replanted to gamalote or guinea grass, or they are rotated with other crops. Cattle are tethered, in numbers as high as 30 animals per herd, in these grass areas.

In the southern and southwestern part of the island the grasslands that are plowed consist almost entirely of guinea grass. The soils are fertile and grow a good crop of forage. Lands that are suitable for irrigation, are planted to sugarcane, if irrigation water is available. The topography of a large area is not suitable for irrigation, and this land is planted to guinea grass and pastured. If grazing is continued over a period of years without plowing, the yield of pasturage becomes extremely low. Plowing the pasture lands in this part of the island differs from that in other regions in that the entire pasture field is not plowed, because the animals would have no feed on the area during the period of reestablishment of the grasses.

Also if the fields are left bare they are subject to severe erosion by both wind and water. Although the rainfall is scanty, it is torrential when it falls. Instead of plowing the entire area, strips about 20 feet in width are ployed on the contour, and seeded to guinea grass, either by sowing the threshed seed or by distributing panicles containing the seed over the area. It may require from several weeks to more than 2 months for enough rain to fall to cause the seeds to germinate, but after they have germinated the seedlings develop rapidly. After the seedlings have once been established they are allowed to develop and mature. The seeds from these plants drop in the areas between the established plants, where they germinate. The density of stand is strengthened in this manner.

In some instances the primitive plow does not turn under the clumps of guinea grass, but leaves them anchored. It tears away only some of the roots at the sides of the clumps. This practice appears to stimulate the growth and development of the plants.

Some pastures that are used in rotation with other crops are established by allowing the fields to grow to volunteer vegetation, consisting mainly of grasses, after the crops have been harvested. These areas are pastured for a period of a few weeks to several years, depending upon the yield of the forage. After the fields no longer produce satisfactory pasturage they are plowed and planted to crops.

GRAZING CAPACITY OF PASTURES

The grazing capacity of pastures varies with many factors, among which are annual distribution of amount of forage, pasture management, provision for supplementary feeds, and botanical composition of herbage. During the rainy season grasses are found in abundance in most pastures, while there is a shortage of feed during the droughty periods. This problem can be solved partly by pasture management. Pastures that are overgrazed revegetate more slowly than those in which there is a constantly adequate supply of forage. When the number of animals per unit area is so large that the grass is grazed close to the ground in the wet season there is bound to be a shortage of feed during the dry season, when the growth of grasses and other plants is retarded. By limiting the number of animals so that a surplus of feed is allowed to accumulate, which can be utilized later during the dry season, this difficulty of feed shortage will not be so severe. There have been a number of instances in the past decade in Puerto Rico where farmers have lost many animals through starvation during the dry season, because they had grazed the pasture close to the ground during the active growing period.

The grazing capacity of pastures may be increased slightly by rotational grazing. This procedure gives the pastures a periodic rest, allowing the grasses to develop a larger amount of forage than if grazed continuously. If animals are tethered the carrying capacity is still further enhanced. The greatest amount of forage that can be produced per unit area can be obtained by cutting the grasses at intervals of 5 to 8 weeks and feeding it as soilage. This procedure can be followed only with tall grasses, and it involves much labor. It is not practical for areas that are adapted only for the production of short grasses.

The grazing capacity varies also with the species of grasses. In general, the number of acres that are required per cow per year for the common species of pasture grasses is as follows: Guinea grass, 1 to 2 acres; Pará grass, 1 to 2 acres; St. Augustine grass, 2 to 3 acres; serrillo, 3 to 5 acres; and lamilla, 3 to 6 acres. Where farmers can provide silage for the animals during the dry season the number of animals that can be kept on a farm is greatly enhanced.

Where farmers have more pasturage than they can utilize, they sometimes pasture animals for other farmers on a rental basis. The price paid for pasturing dry cows and heifers in remote areas ranges from 50c to $1 per month, and that which is paid for milk-producing animals in close proximity to cities or villages ranges from $2 to $3 per month. Occasionally, farmers who operate dairies pasture milk-producing cows for other farmers. Instead of receiving a rental they milk the cows and pay the owner approximately $15 per lactation period for the milk.

RELATION OF PASTURES TO SOIL CONSERVATION

Both the aerial and subterranean portions of the grass plants, which constitute more than 95 percent of the pasture herbage in Puerto Rico, play an important part in soil conservation. Where the plants are scattered, the bare uncovered areas of soil among them are subject to erosion by water on slopes, and by wind on level land, where the soil is loose. On the other hand, where the stand is thick as in well-managed pastures, the grass plants offer mass resistance against soil erosion.

Role of aerial parts of grasses in checking soil erosion.—The aerial parts of the grasses, which comprise the leaves, culms, stolons, and dead residues, check erosion by water chiefly through reducing the impact of the raindrops, spreading the surface runoff, reducing its velocity, and forming a mulch. Wind erosion is checked through reducing the velocity near the surface of the ground. Showers of heavy intermittent rains are frequent in Puerto Rico. Large drops fall from high altitudes, sometimes accompanied by strong winds.

It has been observed that where centipede grass (*Eremochloa ophiuroides*) was planted on banks of road cuts or on terrace banks having a slope of 45° the protected area directly beneath the leaf-covered stolons that extend down the slope protruded one or more inches above the surrounding bare area.

Role of subterranean parts of grass plants in checking soil erosion.—The roots and rhizomes that constitute the main subterranean parts of grass plants have an important role in checking soil erosion. The roots and rhizomes protect the soil continuously. The wide variation in the degree of development and growth habit of roots is based largely upon the class of roots to which they belong, the function of the roots, the method of vegetative propagation of the species, and the soil environment.

Among the functions of grass roots are translocation of water and soluble plant-food nutrients, storage of elaborated plant food, and anchorage. The number and size of the roots usually varies with the most critical function that they must perform. This in turn varies with environment factors.

Soil nutrients and moisture are not found in close proximity in a quantity sufficient to meet the needs of the plants. The roots, therefore, penetrate the soil both vertically and laterally to increase the area from which nutrients and moisture may be absorbed by the root hairs.

One of the important functions of grass roots is to anchor the plant. In general, tall grasses have, not only large primary roots in proportion to the size of the plant, but they also penetrate the soil deeply and have a wide spread. Grasses, like beachgrass, which grows on the coasts of the island where sands are subject to blowing, are dependent not only upon the roots but also upon the rhizomes for anchorage. In soft wet soils annual grasses are sometimes pulled up in grazing before the roots are well anchored. Guatemala grass, which is grown on steep hillsides, is sometimes subjected to strong winds during a rain and is blown over and uprooted.

The function of anchorage also is an important consideration in the use of grasses in controlling erosion in newly-planted terrace outlets. Root development in such species as centipede grass is comparatively slow, and the grasses are washed out easily soon after planting, while the root system of tropical carpet grass develops rapidly and anchors the plants more satisfactorily.

Vegetative propagation originates in the nodes of the culms. It has an important influence upon the development of the roots of grasses. In species of grasses that store comparatively little plant food in the culms or modification of culms, such as rhizomes or stolons, the root system usually is much more developed than in plants that have access to a food supply from these organs during critical periods. The perennial grasses that have a capacity for food storage at the base of the culms form tufts. The plant must rely to a large degree upon its roots for its nutriment in critical periods with the result that the root systems of such species are well developed. Species of short grasses that propagate vegetatively by rhizomes or stolons or both generally do not produce a deep root system.

Strictly tufted grasses generally are characterized by erect culms, with relatively large fibrous roots originating from the crown of the plant. Although the general direction of the large roots is that of an inverted funnel, some of them also assume an almost horizontal direction several inches below the surface of the soil to serve as primary feeders. The large roots serve as an anchorage to the tuft, as well as for plant-food translocation and storage. Some strictly tufted species are zacaton, serrillo, weeping lovegrass (*Eragrostis curvula*), and many others.

The culms of many species are erect and pithy. The tufts enlarge by producing adventitious buds at the crown to form potential culms. Not all of them lengthen to produce inflorescences. The number generally is determined by seasonal conditions of soil moisture and soil fertility. The others remain short and serve for plant-food storage, ready to elongate when conditions are favorable. In extreme drought the weak culms may succumb, and on the other hand, when conditions are more favorable, additional ones are produced.

Some species, like weeping lovegrass, produce miniature clovous young grass plants at the nodes after the seeds are mature. These potential plants are equipped with leaves, culms enlarged at the base, and primordial roots, which are ready to penetrate the soil as the old culm that bears them becomes weaker and drops to the ground. Another species that has a similar tendency is merker grass. Advantage is taken in soil conservation practices of this natural method of propagation by setting cuttings.

The root systems of stoloniferous grasses vary considerably. Strictly stoloniferous grasses have little or no tendency to form dense tufts. Among such species are St. Augustine grass, tropical carpet grass, cintillo, and Swaziland fingergrass or African crabgrass (*Digitaria swazilandensis*). There is a wide variation in the stolons of these grasses, which in most instances can be correlated with their root systems. The stolons of St. Augustine grass are thick and serve as a source of plant-food supply for a long time. Although they are relatively close to the ground they do not adhere as closely to the soil as many of the other species. Few strong roots are formed at the nodes, since the plant can obtain its food supply from the stolons during critical periods. New stolons sometimes creep over the old ones that have been decayed partially, so that when a person walks on the turf it feels like a soft mattress.

Tropical carpet grass behaves in a somewhat different manner. The stolons are large also but creep closer to the ground. The young plants develop rapidly, forming strong roots, and soon lose connecnection with the parent plant. The roots penetrate the soil principally in a vertically downward direction. Old plants retain their vitality, however, for a long time. Swaziland fingergrass forms comparatively thin stolons that primarily act as material for propagation, and the young plants that develop at the nodes must depend on their own root system within a short time after taking root.

Strictly rhizomatous grasses, like guajanilla or Brazil satintail (*Imperata brasiliensis*), are limited in number. In this species strong rhizomes extend for considerable distances from the parent plant from 1 to 2 inches below the surface of the ground. Relatively few shoots form at the nodes, thus leaving the new plants spaced 1 to 2 inches from one another. No dense tufts are formed. Some species, such as mellito and Bahia grass, expand their tufts radially by sending short rhizomes horizontally for only a few inches beyond the periphery of the tuft and then assume an upright position. In Uva grass or wild cane, scaly rhizomes may run above the ground for some distance and then send a branch originating from a node to pierce the soil, thus forming roots beneath the surface, and the main rhizomes continue to extend in length to enter the ground at some distance from the parent plant. Later, shoots develop at the place where the roots have become established. Rhizomes of Bermuda grass function as stolons when they emerge from the ground.

Rabo de zorra and knotroot bristlegrass have rhizomes which are knotty in appearance. Adventitious buds form on the lignified short rhizomes at the base of the culms during the active seasonal vegetative period of the plant. They remain dormant during the dry season and form the new culms of the plant in the subsequent growing season. This development gives the plant an appearance of a loose tuft. The variation in the development of rhizomes in the numerous species of grasses that are found in native pastures permits the formation of a more complete network to hold the soil together and thus prevent erosion.

Among the environmental factors that influence the development of grass roots are moisture, available soil nutrients, compactness of the soil, removal of the aerial parts of the plant, and plant competition. Species that are adapted to dry soil usually have extensive roots, while those that grow in a soil environment that is continually moist have comparatively short roots. There are exceptions to this general rule where grasses are provided with rhizomes from which moisture may be drawn during droughty periods.

The roots of grasses are influenced in their development by the compactness of the soil. In most species the feeder roots are located near the surface and only a few penetrate to lower depths. Short grasses that grow in loose soils have a deeper root system than those that grow in compact soils. This is noticeable especially in pastures, where the roots are found nearer the surface after the soil has become more compact through trampling by livestock.

As soon as the aerial parts have been removed through grazing, the balance between them and the roots is upset and, consequently, the root development is impeded. New rapid-growing shoots will form from the crowns. These are supplied with nutrients from the roots that formerly supplied the portions that were removed. In overgrazed pastures the number of grass roots per unit area is considerably smaller than in pastures where the aerial parts of the plant are allowed to develop.

Role of pastures in checking erosion by water.—The most serious losses of soil on sloping land are through erosion by water (fig. 15). Nearly all of the surface soils on the slopes of the island from a depth of a few inches to several feet are relatively porous and consequently have a high absorptive capacity for moisture. Below the surface layer the interspaces of the soil are filled with fine particles that are packed so firmly that they form an almost impervious layer similar to hardpan. Comparatively little water percolates through this layer; instead it gradually travels along the surface of this impervious layer below the porous topsoil to lower levels. Although much rain falls in frequent intermittent showers, the period of duration of showers usually is not longer than 10 to 15 minutes. The rainfall of most showers is absorbed almost completely by the spongy layer of surface soil in the pastures, and consequently there is little or practically no runoff. When heavy showers of longer duration occur, the porous surface layer becomes saturated, and the additional water runs off on the surface to lower levels, to form numerous deep finger gullies on tilled lands.

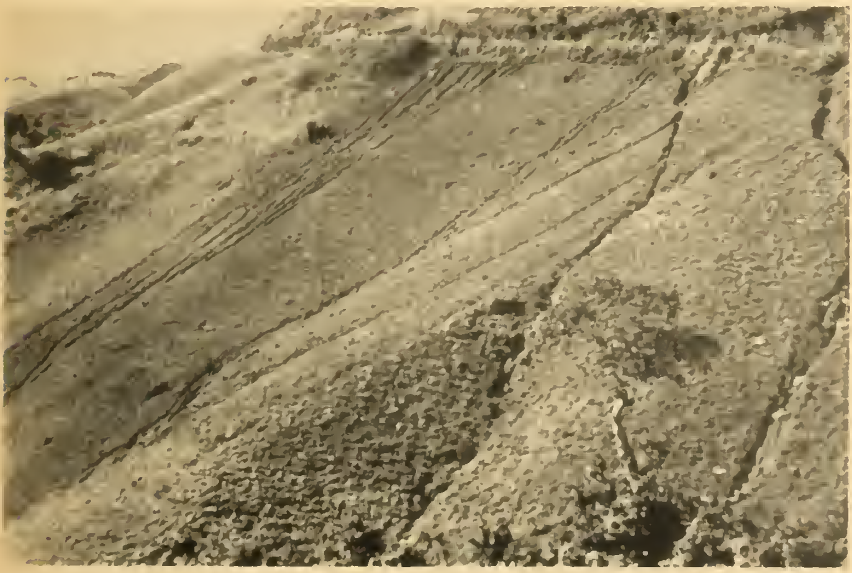

Figure 15.—Erosion by water on a steep slope that has been prepared for and planted to a crop which requires clean culture. No gullies formed where the ground was covered by grasses.

Well-managed pastures suffer comparatively little from soil erosion by water. It has been observed that when lowlands subject to flooding from adjacent streams are planted to sugarcane they lose immense quantities of soil in times of flood. The high water of the river takes a new course across the cultivated fields and carries away many tons of soil before it recedes to its channel. When these areas are covered with pasture grasses, such as Pará grass and Carib grass, little soil is lost. In many instances there is a deposition instead of soil loss after the river has overflown its banks on pasture lands.

Role of pastures in checking erosion by wind.—The main areas in Puerto Rico that are subject to erosion by wind are the sand-dune area near the seashore west of Arecibo, the white-sand area southwest of Arecibo, and the sandy area near the southwest corner of the island. The sand-dune area along the coast is subject to strong northeast trade winds almost throughout the year. The sand is piled in slightly shifting dunes to a height of 20 feet or more. The main grass that is found on and at the foot of the dunes on the windward side is beachgrass. This grass, together with other vegetation checks the translocation of the shifting sands. Since this grass is low in palatability in comparison with other species that grow in the vicinity, little attention is given to pasturage in the dune area.

The sandy area southwest of Arecibo has more fertile soils. Some crops that require intertillage are grown, but most of the area is planted to gamalote and guinea grass. Where these grasses cover the area, wind erosion is checked almost completely.

Near the southwestern corner of the island where the land is subjected to wind erosion, the most common crop is guinea grass, which checks erosion also in this area. Where a crop such as cotton, that requires intertillage, is planted, the soil is ridged at right angles to the direction of the prevailing winds to check erosion.

PASTURE OUTLOOK

A pasture improvement and management program is vital to the conservation of the soil for the general welfare of the people of the island. With the ever-increasing population of Puerto Rico it becomes necessary to conserve all available soil and soil fertility in order to feed the population. In the last half century there has been a tendency to utilize all of the land that is suitable to growing cultivated crops without regard to soil losses through erosion that is incidental to tillage. Considerable attention has been given to improvement and field management of intertilled crops that cause soil losses, while pasture improvement and management and other soil conserving measures have been, for the most part, a "hit or miss" procedure. A rural economy was built around crops that could be marketed directly. After the land had deteriorated, principally through soil erosion, to the point that cropping no longer was profitable, the erodible land was abandoned to volunteer vegetation that was usually low in palatability as well as in yield. Considerable areas of such lands are now used for pasture.

The time has arrived when farmers must maintain the productivity of their soil by saving it from erosion through a proper adjustment of the pasture acreage and the cultivated crop acreage. This will involve an adjustment also between the available pasturage and other forage lands and the number of head of livestock that can be kept on a farm.

Checking soil erosion and maintaining soil fertility are factors that contribute to a higher standard of living. Through proper pasture management, supplemented in many instances with green-cut forage from vegetative protected areas, such as terrace-outlet channels and terrace banks in the cropland where grasses and other close-growing forage plants are planted to check erosion, would enable more farmers to keep one or more cows. This would have a tendency to give more stability to the family income.

The basic grasses around which pastures must be developed are guinea grass in the uplands, and Pará grass and Carib grass in the lowlands. The problem in most areas is to provide adequate grazing throughout the year. At the present time the number of head of livestock is limited by the critical dry period, from January to April. In these areas supplementary feed in the form of green-cut forage or silage must be supplied.

A general pasture-improvement program including planting and proper management practices is necessary to conserve the soil. Old pastures on hillsides should be plowed in alternate strips on the contour and planted to guinea grass. Those lands that are too steep to be plowed should be planted to guinea grass by setting out clumps. When the grass is once established and allowed to reseed itself the stand will be almost perpetual with proper management.

The farm organization on most farms should include a livestock enterprise that is so organized as to provide a proper balance between the number of animals and the necessary acreage for pasture and for forage to be cut and fed green during drought periods. Such an arrangement would enable the farmer to utilize as large an acreage as possible for cash crops and have all the feed he needs for his livestock enterprise.

Pasture management under a systematic improvement and grazing plan would enable farmers to utilize more profitably extensive areas of abandoned land that are now scarred by diamond ditches that were made when the land was being tilled and had not lost its surface soil and fertility through erosion. Where cattle are being pastured on such lands in large numbers there have been instances of losing a number of animals through starvation during critical drought periods. Proper care and management of pastures would not only retain the fertility of the hilly lands of the individual farmers, but would also, as a result, enhance the economic and social welfare of the people of the island.

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